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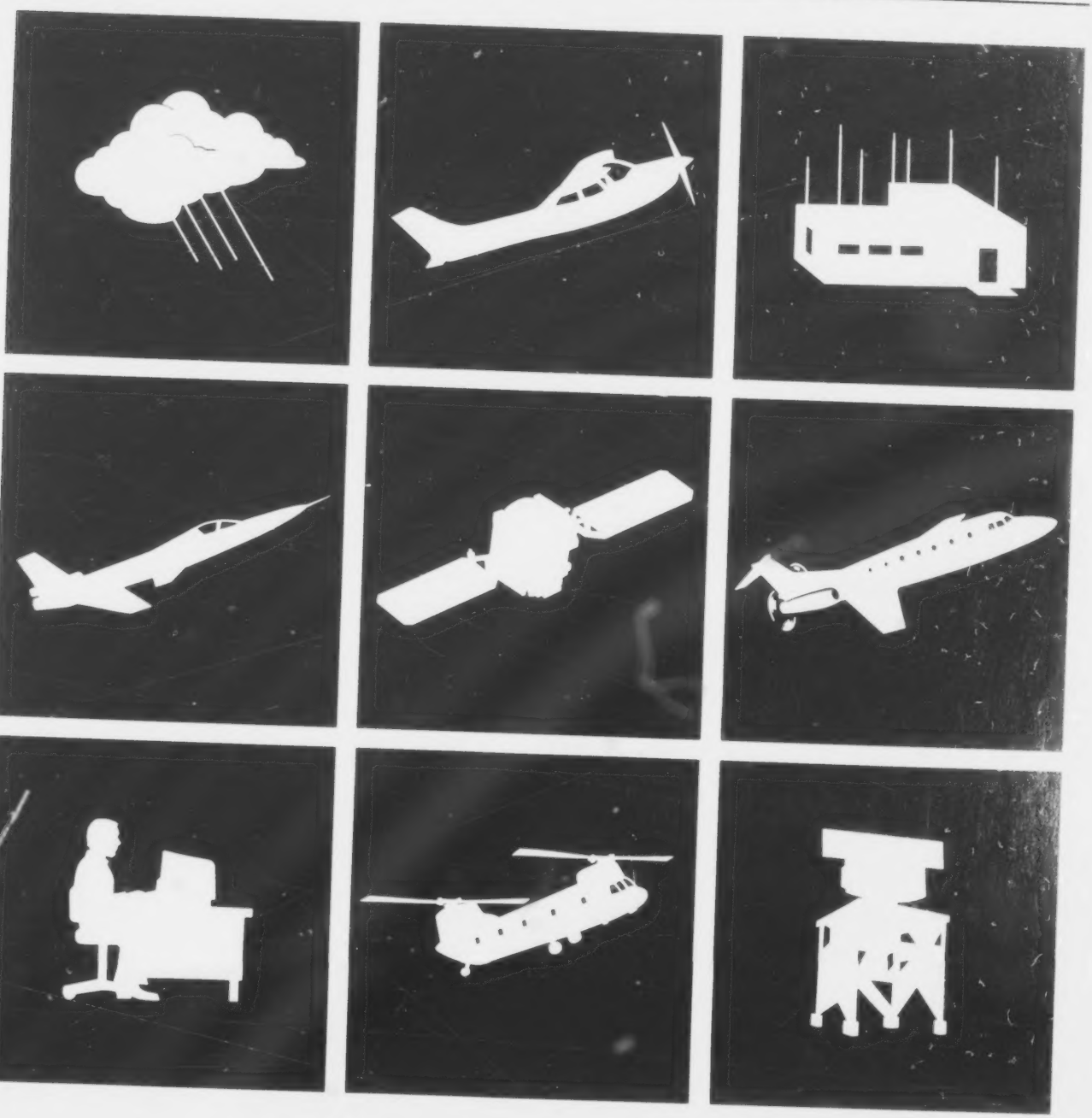
U.S Department
of Transportation
Federal Aviation Administration

The Federal Aviation Administration Plan for Research, Engineering and Development

Volume II
R,E&D Project Plans

October 1985



U.S. Department
of Transportation
**Federal Aviation
Administration**

The Federal Aviation Administration Plan for Research, Engineering and Development

Volume II
R,E&D Project Plans

October 1985

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Washington, D.C. 20402

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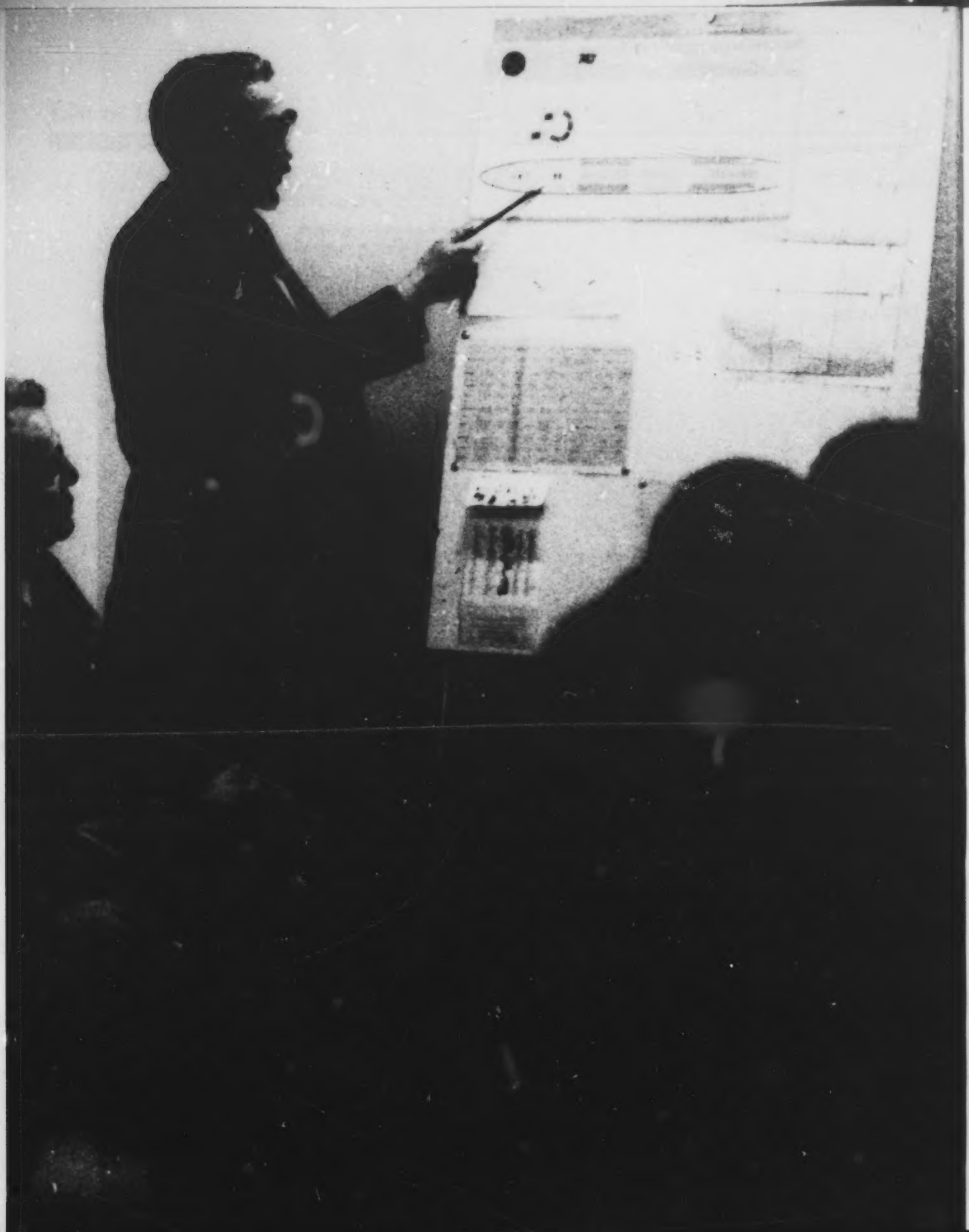


Chapter 1
Guide to Project Plans

An outline of the project plan descriptions in each of 13 technical areas is provided, and the format for these descriptions is explained.

The purpose, scope, and primary objectives of the Research, Engineering and Development (R,E&D) Plan are presented in Volume I. The plan looks far into the future (2015), examining not only potential advancements in technology, but the perspective of the principal users of the National Airspace System (NAS) as well. For planning purposes, the time frame is broken into three "windows," with 1986-95 comprising the near term, 1996-2005 comprising the mid-term, and 2006-15 comprising the far term. In Volume I, a view of the future NAS is presented in Chapter 5, while the perspectives of rotorcraft operators and the Department of Defense (DOD), and characteristics of advanced technology air transport aircraft are presented in Appendices A, B, and C, respectively. These views of the future form the basis on which the various research projects described in this volume have been formulated. An attempt is made throughout to identify the projected benefits, such as safety, capacity, and user and provider productivity, to be derived from each project.

The project plans described in this volume have been organized into 13 technical areas: System Studies (Chapter 2), Air Traffic Control (Chapter 3), Communications (Chapter 4), Navigation and Landing (Chapter 5), Surveillance (Chapter 6), Weather Services (Chapter 7), Satellite Applications (Chapter 8), Avionics (Chapter 9), Airports (Chapter 10), Aircraft Safety (Chapter 11), Aviation Medicine (Chapter 12), Aviation Security (Chapter 13), and Technology Development (Chapter 14). Several projects described in Chapters 3, 4, 5, 6, and 7 are interdependent; that is, the orderly progress of some projects depends on successful completion of certain others. For example, Mode S data link and the Central Weather Processor (CWP) are prerequisites for full development of Automated En Route ATC (AERA). These dependencies are listed in Appendix A of this volume. The projects described in the other chapters may be related in a general sense, but they do not have strong dependencies. Some details on the contents of the various chapters are provided below.

Chapter 2. The process of R,E&D concept development and the generation of a current R,E&D Plan are described.

Chapter 3. The Air Traffic Control (ATC) projects have been divided into four areas: traffic management, flight management, flight information management, and system management. Projects related to traffic management will enhance ATC capability by matching traffic demand to available capacity on a real-time basis. The flight management projects are concerned with providing effective ATC service to individual flights so that they can fly with the least degree of constraint while maintaining safety and overall system efficiency. Flight information management projects are concerned with providing airspace users easy access to accurate and comprehensive ATC information for effective flight planning. Projects related to system management are concerned with identifying requirements, and implementing the tools, procedures, and organization for continually measuring, monitoring, assessing, and improving the performance of the ATC system.

Chapter 4. Communications projects comprise two distinct elements within the NAS—ground-ground interfacility communications and air-ground communications. Interfacility communications cover voice and data transmissions between FAA facilities, such as centers, towers, and radar sites; this element also supports the development of a Voice Switching and Control System (VSCS) and a National Airspace Data Interchange Network (NADIN) for improving these communications. Air-ground communications capability, on the other hand, will be significantly improved by the Mode S data link and its enhancements, which are presently under development.

Chapter 5. The FAA's efforts in the area of navigation and landing will enhance present systems, such as Distance Measuring Equipment (DME), Very High Frequency Omnidirectional Range (VOR), and Non-Directional Beacon (NDB); examine innovative approach and landing procedures using the Microwave Landing System (MLS); and continue to identify an appropriate mix of aids for updating the Federal Radionavigation Plan (FRP).

Chapter 6. Surveillance-related projects consist of efforts to enhance the performance of existing sensors with improved signal processing, to improve airport surface surveillance systems using Airport Surface Detection Equipment (ASDE) and Mode S, to extend surveillance coverage for multiple approaches and rotorcraft operations, and to provide dependent surveillance for oceanic airspace.

Chapter 7. Weather is a critical factor in all flight operations and will continue to be so in the foreseeable future. The projects presented in the weather area will increase the frequency, resolution, and accuracy of weather observations; improve the quality of forecasts; and significantly increase the efficiency of the distribution of weather products.

Chapter 8. The activities under satellite applications will focus primarily on utilizing the Global Positioning System (GPS) as a supplemental navigation system for civil aviation. Technical studies will also be conducted in support of designing an integrated satellite-based communication, navigation, and surveillance (CNS) system.

Chapter 9. The avionics projects will essentially focus on further development of the Traffic Alert and Collision Avoidance System (TCAS), an airborne collision avoidance system that will provide an independent backup to ground-based separation assurance systems, onboard sensors to detect wind shear, and improvements to the avionics certification process.

Chapter 10. The airports projects will provide standards and guidelines for the design, construction, operation, and maintenance of airports. These projects cover several areas, including pavements, runway exits, surface lighting, visual aids, CFR (crash, fire, rescue) services, and others.

Chapter 11. The aircraft safety projects focus on improving aircraft and passenger safety, and cover the two major areas of crashworthiness and airworthiness. These projects will develop improved airworthiness criteria and technical information related to the structural crashworthiness of aircraft and onboard systems, the flammability and toxicity of materials used on board, and icing protection. This activity also includes the development of improved methods for assessing environmental impacts of aircraft.

Chapter 12. The aviation medicine area covers a broad spectrum of work related to medical, behavioral, and human factors technology.

Chapter 13. The aviation security projects are designed to counter the threat of hijackings and terrorism with a comprehensive program of preflight security checks for persons and property, and with the development of operationally viable responses to in-flight bomb threats.

Chapter 14. In addition to the projects in the above areas, the FAA conducts R,E&D for purposes of technology development. This work covers studies in certain basic technical disciplines, such as voice recognition, human factors, wake vortex, wind shear, simulation techniques, and expert systems. The objective of these projects is to develop applications of emerging technologies to meet future NAS requirements.

Appendices A, B, and C contain material that supports information presented elsewhere in this volume. The related R,E&D project prerequisites within this plan are identified in Appendix A. Appendix B presents the expected future evolution of NAS CNS capabilities in matrix format for the near, mid-, and far terms. The R,E&D projects within this plan that directly support NAS Plan projects are shown in Appendix C. Numerical, categorical, and alphabetical indices of all the projects in this plan are presented in Appendix D. The project categories are defined as follows:

Category A—NAS Concepts. These projects are for R,E&D planning and cover activities necessary for keeping the R,E&D Plan current.

Category B—Direct Support of NAS Plan. These are projects in which R,E&D is currently ongoing, as indicated in the NAS Plan.

Category C—NAS Enhancements. These projects provide enhancements to the present and developing NAS.

Category B/C—Direct Support to the NAS Plan with Enhancements. Projects which have either ongoing or planned R,E&D activities, already described by the NAS Plan, and, in addition, contain new activities to enhance or extend NAS capabilities are included in this category.

Category D—Sustaining R,E&D Activities. Projects in this category support development activities in areas such as aircraft safety, aviation medicine, and security.

Category E—New Initiatives. These projects may lead to the application of recent advances in technology and new ideas for many different aspects of aviation.

Appendix E contains a list of Acronyms.

Each R,E&D project described in this volume is assigned a project reference number and is presented in the following format:

Purpose

The overall goal to be achieved by the project.

Category

Alpha designators (A, B, C, B/C, D, or E) are used to indicate the type of project being described, according to the category types listed above.

Approach

An overview of the principal project activities, to include scope and technical approach.

Products

The major tangible products expected from the project, such as reports, prototype equipment, and specifications.

Recent Accomplishments

A list of key project activities that have been completed to date; new projects will not have accomplishments listed.

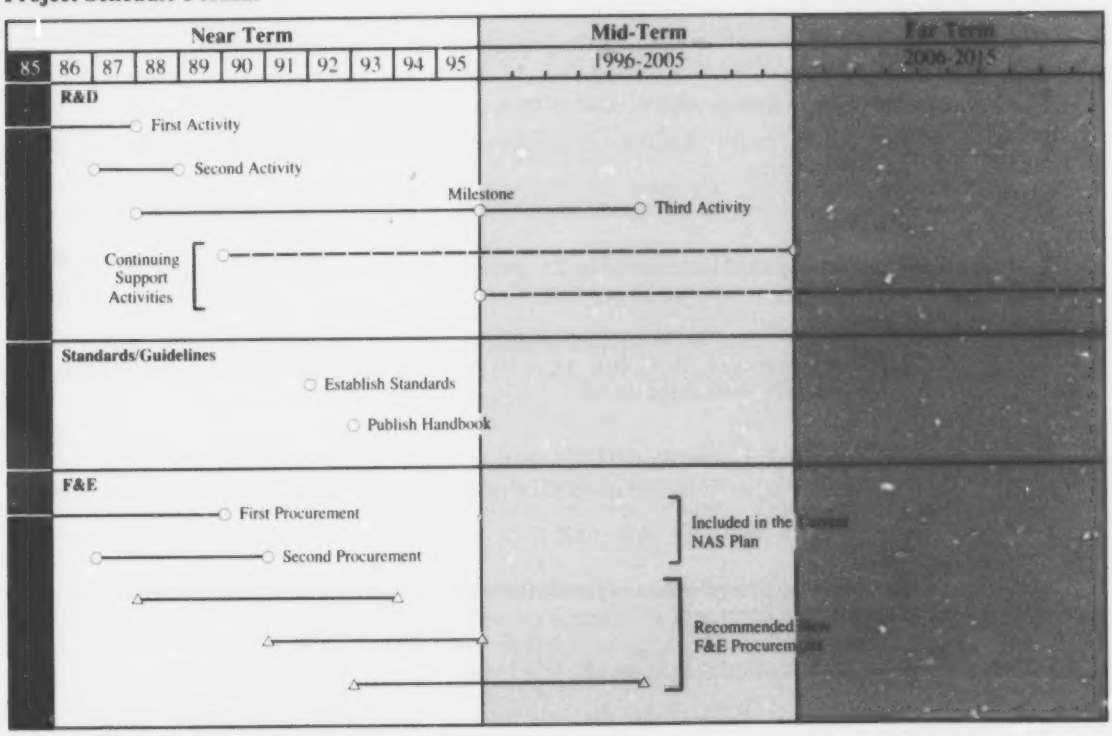
Related Projects/Activities

A list of other projects that are directly related in that they involve activities prerequisite to the R,E&D projects being described. Related project titles are followed by a brief statement of these prerequisite activities. Projects are contained in the R,E&D Plan; when a project falls, for example, under the NAS Plan, the National Aeronautics and Space Administration or the National Weather Service, this is indicated in parentheses next to the project name.

Schedule

The presentation of project schedule information as shown in Figure I. The format uses a standard approach to show various activities and milestones on a time line. These activities are divided into three major groups: the R,E&D activities include those funded under R,E&D appropriations, and every schedule therefore includes this group; the second group includes any standards, guidelines, or procedures resulting from the project activities; the third group comprises the procurement of facilities and equipment (F&E) related to the R,E&D project, but funded through the F&E appropriation. Some of the F&E activities presented here are included in the FAA's current NAS Plan; these are represented by circles on the schedule. Others are recommended to be included in future updates of the NAS Plan on the supposition that the related R,E&D will be successfully completed; these activities are represented by triangles on the schedules. It should be noted that not every project in this plan will include all three groups of activities.

Figure I
Project Schedule Format



Chapter 2
System Studies

System Studies will assess future requirements through evaluation of technological and operational alternatives.

Comprehensive planning in support of the development of the NAS is increasingly important as the demand for air transportation grows, and the NAS is called upon to support a broader spectrum of vehicle types and a greater diversity of flight operations safely and efficiently. An accurate assessment of future requirements and an understanding of the technological and operational alternatives for meeting these requirements are necessary to meet the future challenge. In addition, a long-range plan for the evolution that includes consultation with the user community is required to ensure that the future NAS will meet user needs.

The first project in System Studies addresses the planned evolution of the NAS through continual assessment of NAS performance, demand, and development. Technological and operational development alternatives, their costs and benefits, and anticipated impacts on the NAS will be analyzed. The principal product of this project will be a current R,E&D Plan. Specific system studies will also be conducted in the near future in the program areas of capacity, weather, flexible routing, flight planning, automation, and communications, navigation, and surveillance (CNS). These studies will evaluate R,E&D projects which support these six program areas. Alternative concepts will be developed and evaluated from both functional and cost perspectives. Alternative requirements will be prioritized. Those projects which qualify for near-term starts as well as those which could be highly beneficial will be given special attention. When appropriate, these system studies will be supported by analytical studies, simulations, and actual operating data.

A second project will focus on the 2010 time frame, when technologically advanced vehicles will be operating in the NAS. In this project, studies will examine advanced concepts and technologies that offer opportunities for improving the safety, capacity, productivity, environment, and extension and restructuring of NAS services.

System Studies Project Summary

Area	Project Number	Project Name
R,E&D Plan	2.1	NAS Development Studies
Advanced Concepts	2.2	Advanced Concepts Studies

2.1
NAS Development Studies

Purpose

To develop and maintain a current plan for the long-range evolution of the NAS and to derive therefrom a current R,E&D Plan.

Category

A—NAS Concepts

Approach

The long-range evolution of the NAS is determined by the demands placed on the system, the technological and operational alternatives available for meeting these demands, and the process by which alternatives for development and eventual implementation are selected. If the selection process is to provide a viable NAS for the future, it should be based on a reasonably formal methodology that progresses from requirements analysis to the identification of alternatives for meeting the requirements, the analysis and selection of alternatives for development, and synthesis of a future NAS system concept, including an understanding of this concept's implications. The process must be iterative. Replications are required first as a means for responding to changing requirements, and second as a means for feeding information developed late in the process back into earlier decisions. This evolutionary process will consist of the following activities:

NAS Performance Assessment—The FAA undertakes comprehensive assessments of NAS performance, including accidents and incidents, traffic demand, delays encountered, and NAS facility availability and maintenance requirements. Appropriate information from these existing sources will be accumulated into a performance assessment data base, and analysis will be undertaken to identify areas in which future R,E&D needs may arise. A specific data-gathering effort will be performed to determine actual aircraft performance in the system, since all of the necessary work depends on better understanding of performance in the operational environment. This data gathering will concentrate on terminal area and final approach performance, on-runway performance, and taxi performance, along with up-to-date data gathering on weather and wind variability. For example, trends of traffic activity in high-density areas will be monitored so that capacity saturation can be anticipated and means for coping with such saturation understood.

Demand Analysis—Demand analysis has several dimensions. The magnitude of anticipated future demand is estimated by the FAA Office of Aviation Policy and Plans. Results are published annually at public aviation forecast conferences. The other two dimensions of demand are the increased range of vehicle types and the requirement for the NAS to support efficiently a greater variety of flight operations. These dimensions arise from advances in vehicle technology, and from user operational requirements to employ aircraft for extended commercial applications in expanding regions of the navigable airspace. An accurate assessment of this demand requires close liaison with the national aviation community.

Requirements Definition—The intended result of NAS performance assessment and demand analysis is a quantitative understanding of needs to be met in the future. The planned evolution of the NAS should respond to these needs without sacrificing valuable attributes of the existing system. The requirements definition process breaks down system-level needs into problems that can be addressed more specifically. For example, a requirement to improve the capacity of oceanic airspace could be reduced to requirements for providing real-time surveillance data over the ocean, and for revising oceanic ATC procedures and separation standards to take advantage of this improved surveillance information.

Assessment of NAS Development Plans—Existing plans for the development/modification/evolution of the NAS will be reviewed in an effort to determine the extent to which foreseen requirements have been anticipated. Plans to be reviewed include the existing R,E&D Plan, the NAS Plan, and ad hoc plans such as the Rotorcraft Master Plan and Aviation Weather Plan.

Technological and Operational Assessment of Development Alternatives—The alternatives assessment process identifies viable means for meeting requirements not covered by existing plans. The NAS comprises a diverse array of facilities and associated procedures and practices. The consideration of modifications for meeting future requirements therefore demands a comprehensive understanding of the technical means available for achieving such modifications, and the development of operational concepts for implementing the appropriate NAS enhancements. Hence alternatives analysis necessarily requires both technical and operational assessment of the various means by which requirements can be met. As a result of the specialized nature of NAS ATC and flight operations procedures, the participation of operational specialists at this point in the development planning process is essential.

Cost-Benefit Analysis—After viable development alternatives have been identified, appropriate cost-benefit analyses are necessary to focus on the alternatives with the greatest potential for meeting requirements at acceptable cost levels. Unfortunately, such analyses in the national aviation environment can be complex. A particular difficulty is that costs and benefits can be distributed unequally among user groups so that certain users may appear to derive the benefits, while others appear to bear the costs. Notwithstanding these difficulties, an understanding of relative costs and benefits is important in choosing among NAS development alternatives.

Anticipated Impacts of Proposed NAS Evolution—After development alternatives with respect to specific requirements have been selected, a proposed NAS evolution results from the amalgamation of these lower-level developments into a comprehensive system-wide development plan. The cost and benefit data generated in the previous step help in characterizing the estimated impacts of the foreseen evolution.

Current R,E&D Plan—The R,E&D Plan describes the development work required to ensure the intended long-range NAS evolution. In particular, it organizes the associated development work into specific R,E&D projects with defined products, activities, and schedules.

R,E&D Facility Requirements—The R,E&D Plan also provides a means of defining future requirements for technical and operational expertise within the R,E&D activity, and for R,E&D facilities needed to support the evolution of the NAS. Knowledge of these requirements facilitates collateral plans designed to ensure that resources are available in the time frames required.

Aviation Community Consultation—It is intended that consultations with the aviation user community will be conducted continually during the process described above. The R,E&D Plan provides a basis for formal community response to long-range development plans.

Products

- R,E&D Plan
- R,E&D Facilities Requirements

Recent Accomplishments

- The current R,E&D Plan is a product of the NAS development planning process.

Related Projects/Activities

- Advanced Concepts Studies—New technologies with potential for NAS application will be identified by these studies.

Schedule

Near Term											Mid-Term	Far Term
85	86	87	88	89	90	91	92	93	94	95	1996-2005	2006-2015
	R&D R, E&D Plan										Annual R, E&D Plan Update	

2.2
Advanced Concepts Studies

Purpose

To identify and explore advanced-technology concepts for providing air traffic services; these studies will be focused on the far term, when new vehicles will be operating in the NAS, and air traffic control practices may be significantly different from those in use today.

Category

A—NAS Concepts

Approach

The approach is similar to that applied in the NAS Development Studies project in that future requirements will be estimated, technological alternatives for meeting those requirements assessed, and specific R,E&D projects defined for purposes of further developing promising opportunities. The difference between the projects arises from the focus of this one on the 2010 time frame, when technologically advanced vehicles will be operating in the NAS, the magnitude and nature of demand for aircraft operations may be dramatically different from today's, and it may be reasonable to significantly restructure services provided in the NAS to account for the new requirements and available technologies. This project is an opportunity to approach the NAS with a clean slate.

Requirements analyses will include a consideration of changing demands for transportation as a result of population shifts; the evolving use of other modes of transportation; the extent to which other technologies (especially communications) may reduce the demand for some types of air travel; and the emergence of new vehicles in the NAS, including supersonic and hypersonic aircraft. New technologies to be considered for application in the NAS will include advanced cockpit traffic situation displays that may permit flight crews to better monitor and ensure separation, advanced artificial intelligence applications, and opportunities to automate aircraft control fully for improved safety and increased airport capacity. Automated advisory systems will be investigated to provide traffic, terrain, and airspace advisory information for pilots and controllers in the en route and terminal environments. Automated tower services may prove feasible for sophisticated, unmanned terminal airspace approach and landing guidance.

Products

- Assessment of future requirements for the year 2010
- Assessment of technologies applicable to future requirements
- Descriptions of advanced concepts studies for air traffic services
- Recommendations for new R,E&D projects designed to develop promising technologies/concepts

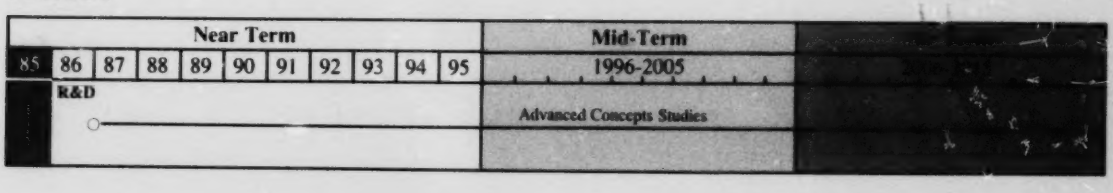
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- NAS Development Studies—These studies focus on the near and mid-terms, and hence provide a background for advanced concepts studies investigations.

Schedule



Chapter 3
Air Traffic Control

ATC service projects will develop hardware, software, and procedures to enhance the flow of air traffic.

Air traffic control (ATC) has been and will continue to be a principal FAA function; it is a service operated by the FAA to promote the safe, orderly, and expeditious flow of air traffic. In support of this mission, the FAA operates several facilities, such as the Flight Service Stations (FSSs), Air Route Traffic Control Centers (ARTCCs), and Airport Towers, and provides other services such as communications, surveillance, navigation, and weather. As indicated in the NAS Plan, the existing en route and terminal radar control facilities will be consolidated from more than 200 today to less than 30 Area Control Facilities (ACFs) by the year 2000; more than 300 nonautomated FSSs will be absorbed into 61 new automated facilities; and an Advanced Automation System (AAS) will replace all en route automation hardware and software, and provide extensibility for terminal automation. The FAA will continually develop the hardware, software, and procedures needed to use the systems provided by the NAS Plan as aids to ATC personnel in performing their tasks.

The current ATC system comprises two main functional elements: a strategic element in the form of traffic management, and a tactical element in the form of flight management. Traffic management is a process by which the traffic demand as a whole is allocated to the available NAS capacity at any given time. It is strategic in nature since it considers the NAS and related variables at an aggregate level and for a relatively long period (2 or more hours) into the future. It involves providing monitoring and prediction of air traffic demand and capacity; identifying potential imbalances between demand and capacity, and possible resolutions of these imbalances; and making traffic flow restriction and traffic delay information available for dissemination to users. Flight management attempts to meet the demands of individual flights safely and with the least degree of constraint. Assistance begins with flight planning and continues through all phases of the flight. This process also ensures vehicle separation by providing timely conflict alerts and resolution advisories. This ATC function is tactical in nature because each of its actions relates to a limited number of aircraft covering a small portion of airspace, and usually involves a shorter look-ahead period of less than 30 minutes.

The ATC system also addresses two other significant areas. The first, flight information management, attempts to provide easy user access, both on the ground and in the air, to accurate data on weather, airport delays, and traffic restrictions, as well as other related information necessary for effective flight planning. The second area, system management, is concerned with continually monitoring, assessing, and improving the performance of the ATC system itself.

The R,E&D projects related to these ATC functions are therefore organized here into the following four areas, described below:

- Traffic Management
- Flight Management
- Flight Information Management
- System Management

The projects related to flight management are further organized here on the basis of the following applicable airspace categories:

- En Route Airspace
- Low-Altitude, Offshore, and Remote Areas
- Terminal Airspace (covering the arrival and departure phases of flight)
- Airport Traffic Area (including the airport surface)
- Oceanic Airspace

The evolution of ATC system capabilities and the user services that may be available in the future are shown in Table I for three time periods. The table lists various future improvements in the functional capabilities of the NAS and its services, and identifies specific R,E&D projects related to these improvements. As indicated, the traffic management and flight management capabilities of the ATC system will be significantly improved, automated, and expanded to cover oceanic and low-altitude airspace before the various ATC elements are integrated into a flow management system around the year 2010. Such a flow management system will automatically provide conflict-free clearances to users in order to accommodate flight trajectories of their preference. This concept of integrating ATC functions is illustrated in Figure II.

Table I
Evolution of ATC System

Area	Near-Term 1998-1999			Mid-Term 1999-2005			Far Term 2006-2015			
	Improvement	R,E&D Project (Number)	Benefit	Improvement	R,E&D Project (Number)	Benefit	Improvement		R,E&D Project (Number)	Benefit
Traffic Management	Match traffic demand to available terminal and en route capacities	Traffic Management System (TMS) (3.1)	UP C	Utilize user-preferred trajectories (UPTs) in traffic management; provide limited accommodation of user requests for airport landing times	Traffic Management with Arrival Time Accommodation (3.2)	UP C	Routinely accommodate user requests for airport landing times	Integrate traffic management functions to provide flow management.	Traffic Management with Arrival Time Accommodation (3.2)	UP C
	Match oceanic traffic demand to available capacity; accommodate flexible route structures	Oceanic Traffic Management (3.4)	C UP	(Evolution)						
Flight Management En Route	Improve ATC computer system capacity, reliability, availability, and extensibility	AAS (3.7)	S C							
	Improve controller—ATC computer system interfaces such as displays and data, entry terminals	AAS (3.7)	PP	(Evolution)			(Evolution)			
	Utilize reduced vertical separations above FL290; study potential for reduced horizontal separations	Separation Standards (3.9)	C UP							
	Enable users to fly preferred trajectories	AERA 1 (3.10)	UP	Accommodate UPTs and provide limited accommodation of airport landing time requests	UPT (3.11)	UP	UPT Evolution—Routinely accommodate UPTs and airport landing time requests	These functions will be integrated with traffic management function to provide flow management.	UPT (3.11)	UP
	Provide conflict probes, limited resolution aids, and reminders to controllers	AERA 1 (3.10)	S PP	Analyze flight plans and associated surveillance data to identify for controllers alternative solutions to resolving airspace and aircraft conflicts	AERA 2 (3.10)	S PP	Analyze flight plans and associated surveillance data to data link computer-generated clearances automatically		AERA 3 (3.10)	S PP
				Analyze flight plans and associated surveillance data to data link computer-generated clearances for very high altitude aircraft automatically	AERA 3 (3.10)	UP PP				
	Utilize aircraft 4D capabilities to meet metering schedules	4D Navigation in ATC (3.12)	C UP PP	Develop controller and pilot procedures and requirements for accommodating 4D navigation in the ATC system	4D Navigation in ATC (3.12)	UP PP	(Evolution)			
Flight Management Low-Altitude, Offshore, Remote Areas	Provide rotorcraft separation services based on real-time surveillance for selected intracity and intercity areas and the Gulf of Mexico	Low-Altitude/ Offshore/Remote Area ATC (3.14)	S C UP	Provide separation services based on real-time surveillance for CONUS integrated with the AAS	Low-Altitude/ Offshore/Remote Area ATC (3.14)	S C UP	(Evolution)	Integrated into flow management		
Flight Management Terminal	Provide dynamic airport capacity estimates and predictions to the traffic management system	Terminal ATC Automation (TATCA) (3.16)	C					Integrated into flow management		
	Provide en route and approach controllers with recommended aircraft-to-runway assignments	TATCA (3.16)	C	Provide controllers with arrival sequence planning information	TATCA (3.16)	C UP PP				
				Provide controllers with computer-recommended separation-assured approach clearances, to include 4D and quasi-4D clearances	TATCA (3.16)	C UP PP	Automatically transmit computer-generated approach clearances to appropriately equipped aircraft		TATCA (3.16)	C UP PP

Flight Management Terminal				Accommodate UPTs to minimize demand on common departure fixes	TATCA (3.16)	C UP PP		Integrated into flow management		
	Develop procedures and separation standards to increase airport capacity based on new runway configurations and associated landing, surveillance, and automation aids	Airport Capacity Improvements (3.17)	C UP	(Evolution)			(Evolution)			
Flight Management Airport Traffic Area				Provide controllers with computer-recommended ground path & release times; implement computer control of ground traffic at intersections	Airport Surface Traffic Automation (ASTA) (3.18)	S PP UP C	Automatically provide ground clearances in all weather conditions	Integrated into flow management	ASTA (3.18)	S PP UP C
Flight Management Oceanic	Provide controllers with a situation display of current aircraft positions based on automatic aircraft position reports	ODAPS Enhancements (3.19)	S	(Evolution)			(Evolution)			
	Analyze flight plans and associated aircraft position reports to identify for controllers aircraft and airspace conflicts	ODAPS Enhancements (3.19)	S UP	Analyze flight plans and associated aircraft position reports to identify for controllers alternative solutions for resolving airspace and aircraft conflicts	Advanced Oceanic Automation (3.20)	PP S	Analyze flight plans and associated aircraft position reports to automatically data link computer-generated clearances for resolving airspace and aircraft conflicts	Integrated into flow management	Advanced Oceanic Automation (3.20)	PP S
	Routinely accommodate flexible tracks	UPT (3.11)	UP	Routinely accommodate UPTs	UPT (3.11)	UP				
	Develop procedures & separation standards to increase oceanic track capacity & flexibility using automatic dependent surveillance and Oceanic Display and Planning System (ODAPS) capabilities	Separation Standards (3.9)	C UP							
Flight Information Management	Improve *ground access* to flight services (Direct User Access Terminals, voice response)	FSAS Enhancements (3.5)	PP UP	Improve *inflight access* to flight services (information and planning via data link for CONUS)	FSAS Enhancements (3.5)	UP PP	(Evolution) Extend data link access to flight services to oceanic and low-altitude airspace		Advanced Oceanic Automation (3.22) Low-Altitude/ Offshore Remote Area ATC (3.14)	UP PP
	Improve flight service data bases (delays, traffic restrictions, weather, special use airspace status information, etc.)	FSAS Enhancements (3.5)	PP UP	(Evolution)			(Evolution)			
				Provide limited accommodation of UPTs and airport landing time requests	UPT (3.11)	UP PP	Routinely accommodate UPTs and airport landing time requests		UPT (3.11)	
System Management	Develop a system for monitoring the performance of the ATC system (e.g., delays, UPT acceptance), and recommend design and organizational changes for enhancing performance	System Performance Monitoring and Assessment (3.21)		(Evolution)			(Evolution)			
	Develop capability to generate fuel-efficient trajectories fully compatible with ATC system	Aviation Fuel Conservation (3.22)	UP	(Evolution)						

C—Capacity
S—Safety
UP—User Productivity
PP—Provider Productivity

Figure II
Evolution of ATC System

Present System	Improvements	System After Year 2010
Strategic ATC		**Automated ATC**
Current Traffic Management Aircraft Release Times for Pacing Airports Arrival Metering Schedules at some Airports	**Improved Traffic Management** Aircraft Release Times Wherever Needed (3.1)* Arrival and Departure Metering Schedules (3.1, 3.6) Runway Configuration Management (3.1) Rerouting (3.1) System Status Information to Users (Delays, Airspace Restrictions) (3.1, 3.3, 3.5)	**Flow Management** Automated Conflict-Free Clearances for All User-Preferred Trajectories System Status Information to Users
Tactical ATC		
Current Flight Management Conflict Alert	**Improved Flight Management** Probes (3.10) Controller Aids for Conflict Resolutions (3.10) Controller Aids for Meeting Metering Schedules (3.1, 3.10, 3.16) Integration of ADS and Conventional Surveillance Data (3.14, 3.19) Controller Aids/Procedures for 4D Aircraft (3.12) Aircraft-to-Runway Assignments and Schedules (3.16) Airport Surface Guidance and Control (3.18)	

*Numbers in parentheses ( ) refer to specific project numbers in this chapter.

Traffic Management

Traffic management is currently carried out at two levels. At the national level, air carrier schedules and weather forecasts are examined at a central facility; estimated departure clearance times (EDCTs) are issued, if necessary to maintain the demand capacity balance, for arrivals to major airports on the basis of aggregate demand and available capacity predicted for up to 8 hours into the future. At the local level, the balancing of demand and capacity is done at each ARTCC, and is based on demand and capacity predicted for up to about 2 hours into the future. Under the NAS Plan, several improvements have already been completed in this area. These include the replacement of old CFC 9020A computers with IBM 4341 computers, the upgrading of data terminals at the Central Flow Control (CFC) facility, and the installation of a data communications system and Apollo computers at each ARTCC.

The R,E&D projects in this area are aimed at providing improvements to traffic management by enhancing data bases, adding software functions, and developing new procedures. In the near term, the accuracy of the prediction of demand and capacity in the terminal, en route, and oceanic airspace will be significantly improved, because these predictions will be based on actual flight plans, better winds aloft forecasts, information on runway configuration status at airports, and other related information. These predictions will be updated as often as necessary for minimizing unnecessary delays. Runway configuration management at single airports, as well as at multi-airport metroplexes, will aid controllers in selecting operationally appropriate runway configurations that provide maximum capacity for given weather, equipment status, and demand conditions. The scheduling of departures will be automated to maximize terminal area departure throughput that is limited by common departure fixes. In addition, alternate traffic management strategies will be evaluated and ranked on the basis of certain performance indices, such as aircraft delays on the ground and in the air, runway usage, and others, so that the most effective strategy can be chosen. Users will also have access to the ATC traffic demand and airport capacity predictions so that they can plan any appropriate corrective action early.

In the mid-term, the traffic management system will allow a certain portion of available capacity at major airports to be used for accommodating preflight user requests for airport landing times; these requests may be modified later in flight if necessary. In the far term, this capability will be expanded so that user requests for airport landing times can be routinely accommodated.

Flight Management

En Route Airspace

The present IBM 9020 computers at each ARTCC will be replaced with modern Host computers in the late 1980s, and the AAS will be commissioned in the early 1990s. Consequently, the capacity, extensibility, reliability, and availability of the ATC computer system will all be significantly improved. The AAS will also provide a highly flexible interface between a controller and the ATC computer. The Flight Plan Conflict Probe and Trial Plan capabilities of Automated En Route ATC 1 (AERA 1) within the AAS will assist controllers in routinely accommodating user-preferred trajectories (UPTs).

The R,E&D projects in this area in the near term will focus on developing new procedures and defining display enhancements for use by controllers and pilots so that 4D navigation capabilities on board an aircraft may be used to meet arrival metering schedules. Separation standards may also be modified to reduce permissible vertical and horizontal separation minima, thus enhancing the flexibility and efficiency of the ATC system.

In the mid-term, the AAS will be enhanced further so that future ATC developments, such as terminal ATC automation, knowledge-based AERA functions, and ATC functional changes necessitated by new generations of aircraft, may be accommodated. AERA 2 will use the latest flight plans and associated surveillance data for providing controllers with resolution advisories on potential aircraft and airspace conflicts. For high-altitude airspace, ATC clearances generated by AERA 3 within the AAS will be automatically transmitted via a data link to appropriately equipped aircraft. ATC system enhancements will be designed so as to allow the receipt and delivery of ATC messages via Mode S data link. New procedures and supporting software will be developed so that the ATC system may accommodate UPTs, including requests for specific airport landing times.

In the far term, automatic transmission of ATC clearances via data link will be extended to lower altitudes and for mixed aircraft equipage.

Low-Altitude, Offshore, and Remote Area Airspace

A low-altitude aircraft tracking system, Loran C Flight Following (LOFF), was developed and demonstrated in the early 1980s. In this system, the Loran C navigation data, aircraft altitude, and other information are transmitted to the ground-based ATC system via a VHF AM channel. Using this or a similar system, R,E&D projects are defined that will provide ATC separation services in the near term to rotorcraft and fixed-wing vehicles in low-altitude urban areas and offshore areas on the Gulf of Mexico and Pacific Coast, where automatic dependent surveillance data can be acquired and displayed to the controller. Beyond the near term, rotorcraft separation service will be extended to more airspace and will be integrated with the AAS. AERA algorithms will also be modified to accommodate UPTs in this airspace.

Terminal Airspace

Terminal ATC facilities are being upgraded under the current NAS Plan. The Automated Radar Terminal System (ARTS) is being provided with more memory so that it can support additional functions, such as Terminal Conflict Alert and Minimum Safe Altitude Warning (MSAW). Interfaces to Mode S and on-site controller training facilities are also under development.

The R,E&D projects in this area are aimed at increasing airport capacity through automation and the development of new procedures. Initial terminal automation will aid controllers in developing aircraft sequences and assigning aircraft to runways for airports with multiple-arrival runways to minimize unnecessary delay. Airport capacity predictions will be continually updated for use in the En Route Metering function. New arrival and departure procedures will be developed for increasing airport capacity, utilizing new runway configurations such as closely spaced parallel runways and separate general aviation (GA) or short take-off and landing (STOL) runways.

In the mid-term, speed advisories, and to a limited extent vectoring advisories, will be provided to controllers automatically to assist them in sequencing and spacing aircraft in terminal areas; thus a planned arrival sequence can be met with minimum aircraft spacing and assurance of required vehicle separation. These clearances will be transmitted via a data link to any aircraft appropriately equipped. Flexible user-preferred arrival and departure trajectories and onboard four-dimensional (4D) navigation capabilities will be accommodated to the maximum possible extent. Aircraft without 4D navigation capability or Flight Management System (FMS) equipment will be provided fuel-efficient quasi-4D clearances based on individual aircraft characteristics.

In the far term, all the clearances, messages, and advisories generated by ATC will be automatically transmitted via a data link to aircraft appropriately equipped. In the absence of a data link, this information may be transmitted to the aircraft via a voice communication in the form of synthetic voice commands.

Airport Traffic Area

In the near term, tower controllers will receive advisories from the Traffic Management System regarding departure sequences and schedules. Airport Surface Detection Equipment (ASDE) will also be available for limited monitoring of surface traffic.

The R,E&D projects in this area are aimed at improving the efficiency of tower operations by integrating NAS systems, adding automation, and developing new systems. In the mid-term, ASDE will be improved by being integrated with the Mode S data link so that individual aircraft can be clearly identified on the ASDE display. The ATC system will generate runway-to-gate ground paths for arriving and departing aircraft for possible use by controllers. When a specific path is selected by the controller, the aircraft on that path will be automatically guided on the airport surface through the runway-taxiway intersections, using either controlled surface lights or appropriate displays in the cockpit.

In the far term, an all-weather ground traffic control system will be available for the automatic generation and delivery of ground clearances and for the control of surface traffic of all vehicles.

Oceanic Airspace

The Oceanic Display and Planning System (ODAPS), and later the AAS, will provide controllers with a current situation display based on flight plans and aircraft positions from automatic dependent surveillance (ADS). This system will be enhanced within the near term with an R,E&D project aimed at developing a flight plan probe to monitor aircraft separation in near-real time. These improvements and the expected reduction in permissible separation minima will result in increased track flexibility and capacity in the oceanic airspace.

In the mid-term, flight plans and associated aircraft position data will be analyzed, and advisories will be generated to assist the controllers in resolving potential airspace and aircraft conflicts. In the far term, these conflict resolution advisories will be automatically transmitted to the aircraft via a data link.

Flight Information Management

In the near term, Direct User Access Terminals (DUATs) will provide easier access to improved flight service facilities having synthetic voice response capabilities. The R,E&D projects in this area are aimed at expanding the flight service data base to include route-oriented weather forecasts, airport delays, and traffic restrictions, such as status of special use airspace.

The direct access to flight service facilities will be available in flight via a data link for conterminous U.S. (CONUS) and oceanic airspace in the mid- and far terms, respectively. The ATC system will also be able to accommodate UPTs and requests for airport landing times, both preflight and in flight.

System Management

Currently, the performance of the ATC system is monitored by semi-automated techniques. The R,E&D projects in this area are aimed at developing and integrating data bases to provide a timely ATC system performance monitoring capability. The overall performance of the ATC system itself will be continually monitored so that various elements of the system can be improved on a sound basis. Appropriate performance indices, such as near midair collisions, operational errors, ground and air delays, and the number of UPTs accepted as a percentage of total requests, will be used for evaluating ATC system performance. All the elements of the ATC system will be designed to facilitate such performance monitoring. An operational organization and related procedures will be developed for assessing the system performance and for correcting system problems identified by such an assessment in a timely manner. Such a system will be developed within the near term and will be updated as required in the future. ATC system procedures and related algorithms will also be developed to facilitate aircraft operations with minimum fuel consumption.

The R,E&D projects described in this chapter involve dependencies on other projects in this R,E&D Plan, as well as in the NAS Plan. These dependencies are identified individually in the project write-ups, and are also listed separately in Appendix A.

Air Traffic Control Project Summary

Area	Project Number	Project Name
Traffic Management	3.1	Traffic Management System
	3.2	Traffic Management with Arrival Time Accommodation
	3.3	Dynamic Special Use Airspace Management
	3.4	Oceanic Traffic Management
Flight Information	3.5	Flight Service Automation System Enhancements
Flight Management		
En Route	3.6	En Route Enhancements
	3.7	Advanced Automation System
	3.8	Advanced Automation System Enhancements
	3.9	Separation Standards
	3.10	Automated En Route ATC
	3.11	User-Preferred Trajectories
	3.12	4D Navigation in ATC
	3.13	Area Control Facility Backup
Low-Altitude/Offshore/Remote Areas	3.14	Low-Altitude/Offshore/Remote Area ATC
Terminal	3.15	Terminal Enhancements
	3.16	Terminal ATC Automation
	3.17	Airport Capacity Improvements
Airport Control Area	3.18	Airport Surface Traffic Automation
Oceanic	3.19	Oceanic Display and Planning System Enhancements
	3.20	Advanced Oceanic Automation
System Management	3.21	System Performance Monitoring and Assessment
	3.22	Aviation Fuel Conservation
	3.23	Fuel Shortage Contingency Planning

3.1
Traffic Management System

Purpose:

To enhance ATC system capabilities to monitor air traffic demand on saturable resources, such as airports, fixes, and sector airspaces; to predict and identify imbalances between demand and capacity; and to provide traffic management specialists with tools for evaluating and selecting traffic management alternatives, such as ground delays and reroutes, that can be used in efficiently matching traffic demand to the maximum available capacity. The Traffic Management System (TMS) will also provide users with flight planning information related to current or predicted delays, and traffic flow restrictions for user-identified routes, destinations, and time periods.

Category

B—Direct Support of NAS Plan

Approach

The TMS is made up of two components: the Central Flow Control Function (CFCF) is the national component that provides the general balancing of demand to the maximum available capacity based on up to 8-hour predictions into the future; the local traffic management function is performed by the Traffic Management Unit (TMU) located at each ARTCC or ACF, which matches local demand to local available capacity on the basis of up to 2-hour predictions into the future. The TMS project will develop the following functions:

- Departure Flow Metering (DFM)—DFM will utilize such data as proposed flight plans, current departure schedules, actual departure clearance requests, and other relevant data to generate a set of departure slots that satisfies all applicable local and national traffic flow restrictions. The traffic management coordinators and tower controllers will be able to use this function while performing difficult tasks. Examples of such tasks include scheduling departures from multiple metroplex airports when departure demand exceeds the capacity of common departure fixes or sectors serving those airports, and scheduling departures from single airports when departure demand exceeds runway/taxiway capacity, while simultaneously meeting multiple local or national departure flow restrictions. Part of this task will involve developing and testing an engineering model of DFM at an ARTCC that supports major metroplex airports. The test results will be used to develop a functional design specification for the AAS.
- Definition of System Performance Indices—Operational data on proposed and actual arrival and departure times, estimated departure clearance times (EDCTs) issued by CFCF, and the like will be examined, and air traffic operations will be simulated to define a consistent set of system performance indices. These indices may include delays in the air and on the ground, controller and pilot workload, extra fuel consumption of aircraft, and many others. These indices will be used to upgrade CFCF algorithms, and to assist traffic management specialists in evaluating and selecting traffic management alternatives for resolving predicted imbalances between demand and capacity.
- Automated Airport Capacity Calculations—This function will predict airport capacity in terms of aircraft acceptance rates as a function of planned runway configurations, predicted weather, predicted mix of aircraft types and their capabilities, and predicted arrival and departure demand characteristics. This model will be evaluated through appropriate field tests and modified as necessary.
- CFCF Sector Suite Graphics—This function will generate graphics for use by CFCF traffic management specialists in examining current or predicted traffic flow problems. It will include the capability of highlighting specific direct routes and different Central Flow Weather Processor (CFWP) products. Alternate graphic displays will be examined for purposes of specifying the size, color features, and sector selection capabilities.
- Advanced TMS-1—Several improvements will be implemented in TMS Phase II, at both the local and national levels. These will include the following:

Runway Configuration Management System (RCMS)—This system will be developed as an aid for the TMU and tower controllers to use in selecting the appro; riate runway configurations in local and metroplex operations. The RCMS will select and display an airport capacity rank- ordered list of runway configurations as a function of current and predicted weather conditions, the operational status of facilities and equipment, and the arrival and departure demand profile of the airport. Field tests will be conducted to determine the impact of TMU decisions on the national traffic flow strategy.

Upgrade Arrival/Demand Management Algorithms—An analysis will be performed as a first step in defining and implementing specific modifications of CFCF EDCT algorithms to account effectively for prediction uncertainties. This analysis will address operational data on arrival, departure, and en route flying times, as well as the availability of continually updated flight information, such as cancellations and boundary crossing times. The modified algorithms will then be evaluated through traffic simulations and appropriate field tests.

Direct User Access to TMS Information—This task will develop capabilities in the CFCF computer to provide users with traffic management information, such as delays, flow restrictions, and status of special use airspace. Users will have direct access to this information, either through the Flight Service Automation System (FSAS) or AAS, or through the CFCF computer data base.

- Advanced TMS-2—This will represent a major enhancement to local and national TMS capabilities. The Advanced TMS-2 tasks will include the following:

Generation of Traffic Management Automated Alternatives—This function, possibly a knowledge-based system within CFCF, will automatically provide traffic management specialists with a set of traffic management alternatives for resolving identified imbalances between demand and capacity. These alternatives may include the control of preferred routes between city pairs. Each alternative will be characterized by specific system performance indices so that the traffic management specialist can select a particular traffic flow strategy that will achieve the required traffic management performance. These algorithms will be evaluated through necessary air traffic simulations and field tests; they will then be modified to correct any deficiencies.

TMU Airspace Structure and Restriction Assessment—This task will develop functional requirements for an AAS capability to assess the use of local airspace structures and restrictions. This assessment will ensure that restrictions such as preferential routes, altitude restrictions, and in-trail spacing can be justified on the basis of expected traffic, capacities, and weather. For this task, data on the traffic and workload characteristics of sectors, the airway, and the terminal airspace will be collected as a first step in formulating an initial concept. Preliminary algorithms will then be developed and evaluated in simulated traffic and in limited field tests.

Products

- Functional design of a DFM engineering model
- Performance analysis and user evaluation of the DFM engineering model
- DFM functional design specification for AAS
- CFCF—NAS en route testbed model
- TMS performance indices functional specification
- Functional specification for CFCF automated airport capacity calculations
- Functional specification for CFCF Sector Suite graphics
- Functional requirements and specifications for RCMS for multiple airport complexes with dependent runway configurations
- Functional specifications and operational requirements of local airspace structure and restriction assessment within the AAS
- Analysis of accounting of CFCF prediction uncertainty in the EDCT arrival demand management algorithms
- Functional requirements and specifications for direct user access to TMS information
- Functional requirements for automated generation of TMS problem-resolution alternatives

Recent Accomplishments

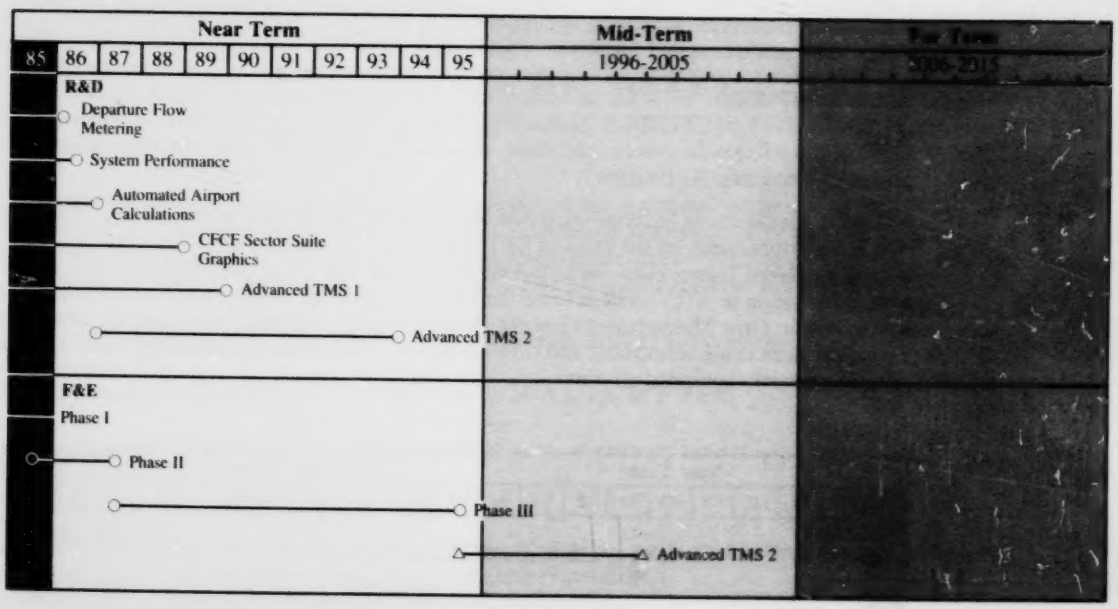
- Report on arrival resequencing published.
- Report on departure resequencing published.

- Initial TMS development plan published.
- Basic route density graphics design for CFCF developed.
- Automated airport capacity calculation development plan published.
- DFM concept report published.
- Static runway configuration management system display installed at O'Hare Airport (ORD).
- Report FAA-EM-82-5, "Overview of ORD Runway Configuration Management System," published.
- Report FAA-EM-82-28, "ORD Runway Configuration Management System Software Description," published.
- Report on DFM Concept published.

Related Projects/Activities

- En Route Metering II (NAS Plan)—ERM II provides CFCF with arrival delay predictions, RCMS with arrival demand estimates, and DFM with calculated departure times (CDTs).
- FSAS Enhancements—FSAS will provide TMS with Visual Flight Rules (VFR) flight plan data for demand analysis.
- Automated En Route ATC—data from AERA and the AERA algorithms are required by the TMU traffic management coordinator in defining, evaluating, and controlling local traffic flow restrictions and alternate reroutes to resolve local traffic flow problems.
- Central Weather Processor (NAS Plan)—provides traffic management specialists and coordinators with current and predicted weather information for use in traffic management.
- Storm-Scale Operational and Research Meteorology Program (NOAA, DOD, DOI, DOT, EPA, NASA, NSF)—provides TMS and AAS with improved current data on and forecasts of winds aloft.
- Dynamic Special Use Airspace (SUA) Management—will provide guidelines for evaluating the impact of the activation and release of SUA on national or local traffic management.

Schedule



3.2
Traffic Management with Arrival Time Accommodation

Purpose

To develop operational procedures and associated processing capabilities that will enable the TMS to accommodate user requests for airport landing times.

Category

E—New Initiatives

Approach

An air traffic model will be developed to simulate operations with a mix of aircraft with and without 4D navigation, and requesting UPT-related time-based clearances over some or all phases of their flights, including airport landing. These simulations will utilize the enhanced demand information that will be available because of the aircraft's capabilities to request and honor time-based clearances through the UPT facilities, and because of the enhanced capacity estimates resulting from improved algorithms and weather predictions. The simulations will be used to develop operational procedures and requirements for TMS algorithms, displays, and other aids so that the ATC system can accommodate user requests for airport landing times. The impacts of mixed equipage will be fully evaluated. The TMS will be enhanced in two phases. Phase I enhancements will allow TMS to accommodate arrival time requests on a limited scale; for example, a certain portion of available capacity at major airports may be used for such requests before a flight, or if necessary, in flight as well. Phase II will extend these capabilities to permit routine arrival time accommodation.

Products

- Report on feasibility of accommodating user requests for airport landing times
- Report on procedural and functional requirements for use of TMS to accommodate landing time requests
- Report on procedural and functional requirements for routine accommodation of landing time requests

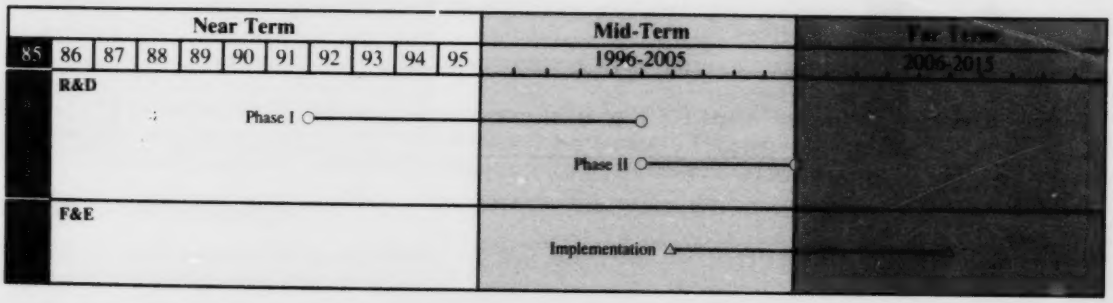
Recent Accomplishments

None

Related Projects/Activities

- Traffic Management System—will develop the basic capability to predict arrival delays, arrival demand, and departure times on the basis of UPT requests and available capacity.
- User-Preferred Trajectories—will develop the basic ability of the ATC system to accommodate UPT.
- 4D Navigation in ATC—will develop the basic ability of the ATC system to accommodate 4D navigation.
- Air Traffic Flow Management Concept (NASA Ames)—will study concepts for terminal air traffic management using scheduling and time control (4D) techniques applicable to both 4D-equipped and conventionally equipped aircraft.

Schedule



3.3
Dynamic Special Use Airspace Management

Purpose

To develop procedures and define automation requirements for increasing flexibility in the use of special use airspace (SUA) by military and civilian users.

Category

C—NAS Enhancement

Approach

The activation and release of SUA, such as restricted airspace and military operations areas, are currently limited by several factors; these include, among others, manual interagency coordination and procedural difficulties. The allocation and control of SUAs are therefore often not totally responsive to either military or civilian needs. New ATC procedures and necessary automation requirements will be developed for the dynamic management of SUAs. This project will be divided into several tasks, as follows:

- Interagency Coordination—Current interagency coordination procedures will be examined in an effort to identify elements that would need to be revised and specific areas that are currently limited by a lack of sufficient automation. Modified operational procedures will then be developed for better coordination between the FAA and the Department of Defense (DOD) so that civilian and military SUA access requests can be accommodated rapidly and equitably.
- Database and Communications Requirements—Requirements will then be developed for a database structure and related communications system that will form the basis of the dynamic management of SUAs. The database requirements will cover several areas, such as questions of user access and restriction, database mechanisms, and intersystem database consistency.
- Automation Requirements—Functional requirements will be developed for ATC automation that will support the modified SUA operational procedures. This will be done for the TMS at the national level for the Central Flow Control function, and at the local level for the AAS at ARTCCs or ACFs. SUA ATC automation requirements will cover several technical areas, including, among others, the following:

  Assessment of the impact, at a national or local level, of the activation and release of SUA—This assessment will consider the number and identity of aircraft affected by the requested or planned SUA activation or release. The sensitivity of this impact to alternate activation times will also be examined in an effort to see, for example, if fewer aircraft can be affected by delaying SUA activation for some time.

  Dynamic definition of SUA to satisfy emergency or high- priority requirements.

  Accommodation of military UPTs to and from an SUA at the ACF level.

  Assessment of the impact, at the national or local level, of reroutes around a specified SUA.

Products

- Report on SUA operational procedures—current limitations, recommendations for improvement
- Report on SUA ATC database and communications requirements
- Report on SUA for ATC automation functional requirements

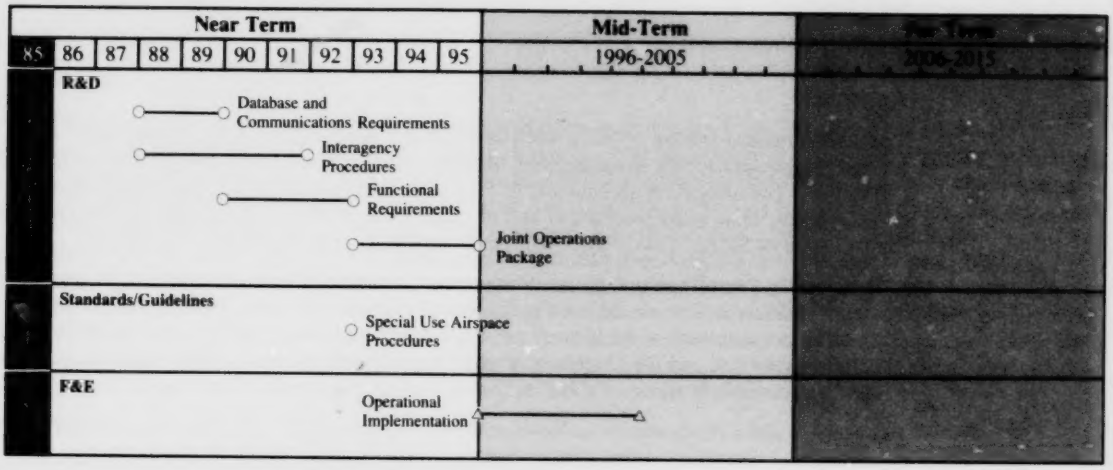
Recent Accomplishments

None

Related Projects/Activities

- Traffic Management System—assesses the impact of SUA on civilian and military traffic.
- Oceanic Traffic Management—assesses the impact of SUA in oceanic airspace.
- Automated En Route ATC—provides capabilities for assessing the impact of military UPTs.
- Advanced Automation System—will provide traffic management automation for assessing the impact of SUA activation and alternate reroutes around the active SUA.

Schedule



3.4
Oceanic Traffic Management

Purpose

To develop flexible route structures and traffic management concepts that will enable the ATC system to better accommodate user demands in oceanic airspace.

Category

C—NAS Enhancement

Approach

Functional and operational requirements for improved oceanic traffic management will be defined as a step towards an integrated oceanic ATC. Traffic management algorithms will be developed for predicting aircraft demand on oceanic airspace in terms of such indices as densities or sector workload, and for evaluating traffic patterns. Algorithms will also be developed for predicting likely imbalances between the traffic demand thus computed and available airspace capacity, and for assisting oceanic traffic managers in developing resolution strategies. Finally, software will be developed for automatically selecting the most effective strategy for use by the oceanic traffic managers.

Automation aids and operational procedures will be developed for defining flexible tracks in the oceanic airspace as a function of given weather patterns and user demand so that the fuel efficiency of oceanic air traffic can be increased. The possible impacts of offshore rotorcraft traffic will be examined.

The automatic probes, route definition algorithms, and other software developed under this project will be tested and evaluated, and if necessary, modified with the help of air traffic simulations.

Products

- Assessment of current oceanic traffic management practices
- Operational and functional requirements for improved oceanic traffic management
- Comparative assessment of alternate strategies for accommodating flexible tracks and UPTs in oceanic airspace
- Specifications and operational guidelines for accommodating flexible tracks
- Requirements for integration and interface with traffic management in CONUS

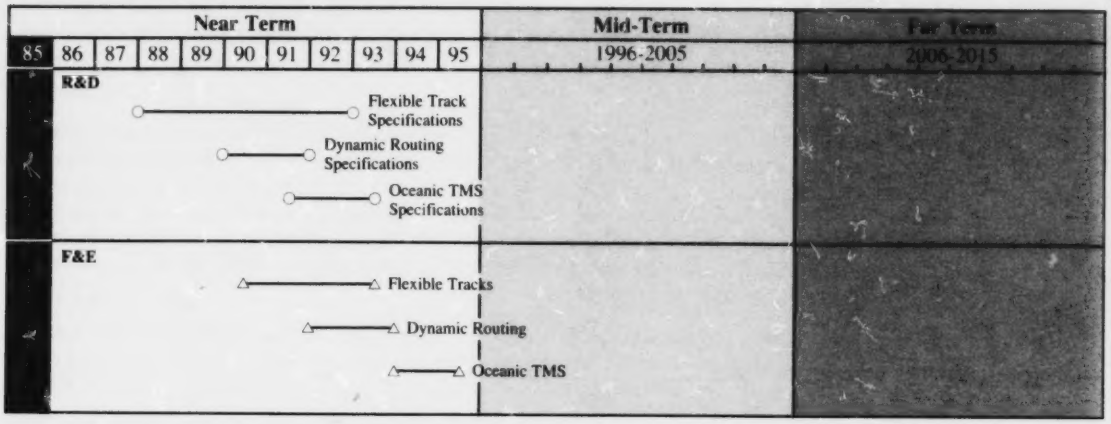
Recent Accomplishments

None

Related Projects/Activities

- Aviation Fuel Conservation—will provide the basis for the definition of fuel-efficient routes.

Schedule



3.5
Flight Service Automation System Enhancements

Purpose

To enhance the Flight Service Automation System (FSAS) to permit easier, prompt, and direct delivery of flight-critical and flight planning information to users.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

The FSAS Model 1 system, currently under development, will provide alphanumeric weather information to the flight service specialist and flight plan filing service to FSAS users. The FSAS Model 2 will add graphics and weather radar data for FSAS specialists, and will also provide a basic interface for direct user access. This program will enhance the FSAS further to permit easier, rapid, direct, and timely delivery of flight-critical and flight planning information to users. This will be accomplished in four steps:

- Package 1—A voice response system (VRS) and ground-air voice transmission of local area weather will be provided. FSAS interfaces to the Automated Weather Observing System (AWOS), Central Weather Processor (CWP), and Weather Message Switching Center Replacement (WMSCR) will also be defined.
- Package 2—This package will provide the FSAS with Aviation Route Forecast (ARF), Center Weather Service Unit (CWSU) interface, flight plan filing, and expanded VRS weather products. Interfaces with Mode S data link for the transmission of flight planning and weather products will be developed. Different products for en route briefings will be defined.
- Package 3—Flight Service Station (FSS) automated information and planning services will be improved to include information on SUA and military routes and access to the TMS data base. Functions available to the DUATs and the VRS self-briefing terminals will be expanded. Specialists will be provided with Geostationary Operational Environmental Satellite (GOES) images. Automated database and enhanced specialist aids will also be incorporated.
- Package 4—Weather data will be broadcast via VHF Omnidirectional Range (VOR) for in-flight coverage, and automatic direction finder computations will be provided to pilots. En route and terminal weather transmissions to aircraft will be automated, and the VRS will be upgraded to accept voice inputs.

As a first critical step in the development of these packages, a system architecture will be defined for an integrated system that will accommodate the above FSAS enhancements. This definition will include the sizing of computer and communications systems, interface specifications, and the establishment of Mode S protocols. All of these packages will be evaluated extensively by means of testbed simulations and service tests.

In addition to these R,E&D activities called for in the NAS Plan, a knowledge-based weather database system will be evaluated for use in flight planning, and for providing improved in-flight services, such as automatic updates of route-specific weather and other products via data link.

Products

- Functional specifications and interface requirements for architecture of enhanced FSAS
- Prototype enhancement packages 1 through 4
- Functional specifications for automatic route-specific updates and for weather-based route planner

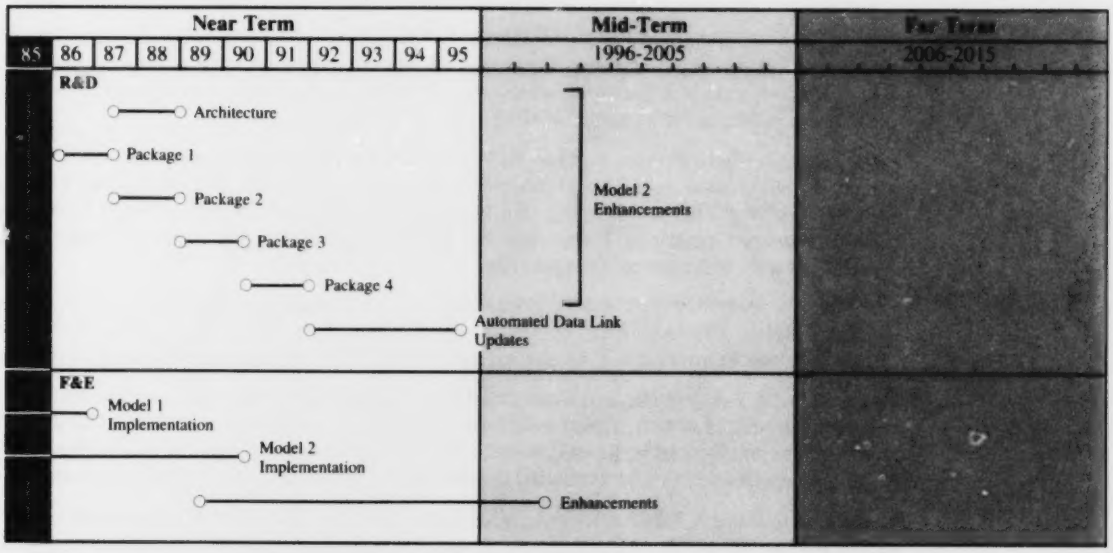
Recent Accomplishments

- Integration of Model 1 hardware successfully tested.
- Model 1 software build test completed.

Related Projects/Activities

- Advanced Automation System—will provide ATC data and processing for flight plan acceptance and feedback.
- Traffic Management System—will provide traffic flow restriction and delay data to the FSAS.
- Central Weather Processor (NAS Plan)—will provide current and predicted weather information via the enhanced FSAS.
- Mode S Data Link Applications—the Mode S data link will provide the means for in-flight direct access to FSAS services.

Schedule



3.6
En Route Enhancements

Purpose

To provide continued development and support for the modern Host computer replacement program. The resultant increase in processing capacity will support interim system improvements under development for the en route operational software.

Category

C—NAS Enhancement

Approach

The 9020 computers presently in use at the ARTCCs will be replaced as part of the NAS modernization. Selection of the Host system was based on a Design Competition Phase that included extensive system tests performed at the FAA Technical Center. The Host must be instruction-compatible with the 9020, with only minimal changes permitted to the operational software.

This R,E&D project will assist in the development of interfaces and the modification of current operational software to accommodate the Host computer system. The Host will provide increased computer capacity to accommodate enhancements and additional functions for the en route ATC system. Necessary development and support for these enhancements will also be provided by this R,E&D project.

- En Route Metering (ERM) II will provide the interface to the Central Flow Control Function (CFCF) for receiving data on proposed or active flights and ground delays. Adjacent centers will also forward arrival flight plan data to the metering center so that the planning interval will be independent of the metered airport's distance to its center's boundary. ERM II will utilize the CFCF delay data in establishing, maintaining, and scheduling priorities so flights are not penalized for prior ATC delays. It will also develop algorithms to provide fuel-efficient delay advisories that will assist the controller in meeting the ERM meter fix or boundary crossing times.
- The Conflict Alert IFR/VFR Mode C Intruder function will extend the current conflict alert function to identify potential conflict situations between IFR aircraft and VFR aircraft equipped with altitude-reporting (Mode C) transponders.
- The Conflict Resolution Advisory function will provide en route radar controllers with a display of alternate ways of resolving conflicts identified by the conflict alert algorithm. Development of this function is a transitional step toward the development of a similar function in the AAS.

All of these functional capabilities will undergo testing and evaluation at the FAA Technical Center before being implemented in en route ATC system operational software.

Products

- Implementation package for Host computer system modified en route software
- Implementation packages for functional enhancements to the en route software

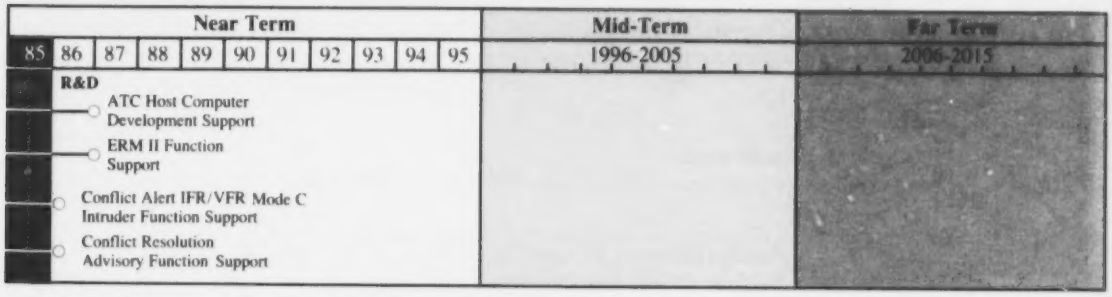
Recent Accomplishments

- Contractor selection made for Host Design Competition Phase.
- Two Host computers delivered to FAA Technical Center for test and evaluation.
- Computer program functional specifications for enhancements to en route software completed.

Related Projects/Activities

None

Schedule



3.7
Advanced Automation System

Purpose

To develop a fully automated ATC system with new processors, software, controller displays, and data entry devices that will enable controllers to handle projected traffic demand and associated workload increases in a safe and efficient manner.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

The AAS will replace all the existing en route automation hardware and software, and will include all the terminal automation functions when implemented in the consolidated ACF environment. New controller workstations, called Sector Suites, will be designed to improve all aspects of the human interface to the automation system. The ATC automation enhancements, such as AERA and Conflict Resolution Advisory, developed during the NAS modernization will be incorporated into the AAS software.

The AAS will be developed in two phases: initially, two contractors will each develop a complete AAS system design, including a subset of the AAS to be deployed at ARTCCs prior to the full AAS. The FAA will then select one of these two contractors for full system development and acquisition based on technical, management and cost proposals. AAS system development and the transition to AAS implementation will be achieved in the three stages described below.

First, the controller displays and data input/output devices of the Sector Suites will be developed for deployment at ARTCCs, and will be used with the Host computer and 9020 software. A major enhancement in this system will be the electronic display and manipulation of flight strip data. The Sector Suite equipment will be reconfigurable so that the controller workstations may be set up for en route or terminal radar control from consolidated ACFs, and for air traffic control simulation training, traffic management, supervisory, and other ancillary positions.

Second, the en route and terminal automation systems of the AAS will be developed. These systems will incorporate AERA and additional software functions that will be developed under AERA and other projects. New computer software and processors will be introduced to augment or replace the Host computer, if necessary.

Finally, tower suites will be deployed, and terminal radar control will be operationally integrated into the ACFs. The en route and terminal operations will then be consolidated in the ACFs.

A requirements validation team of ATC controllers has been formed to assist in the development of the Sector Suite. This group will assist in defining man/machine interface (MMI) requirements and specifications for the AAS.

In addition to these R,E&D activities called for in the NAS Plan, an operational package for AERA 2 will be developed for implementation in the AAS once the specifications become available.

Products

- AAS production specifications
- Sector Suite prototype specifications
- Sector Suite prototype development and demonstration test report
- Operational concept of AAS MMI
- Sector Suite MMI functional capabilities and performance
- Sector Suite console requirements specifications

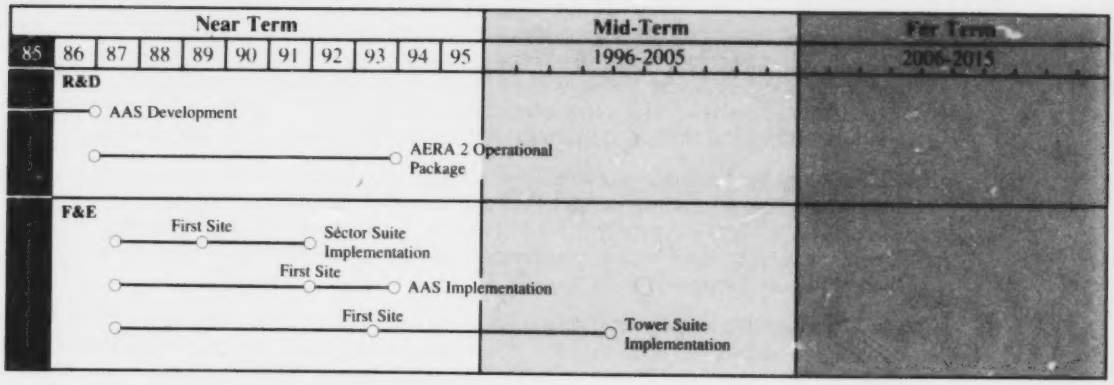
Recent Accomplishments

- AAS functional specifications developed.

Related Projects/Activities

- Automated En Route ATC—will develop functional specifications for AERA 2 and AERA 3 for implementation in the AAS.
- Voice Switching and Control System—will provide voice communications switching and control for the Sector Suite.
- Area Control Facilities (NAS Plan)—will provide consolidation of en route and terminal control facilities.
- ATC Host Computer (NAS Plan)—will replace current 9020 hardware in ARTCCs.

Schedule



3.8
Advanced Automation System Enhancements

Purpose

To enhance the AAS so that the ATC software can accommodate new aircraft types and associated separation standards; to examine advances in computer technology for possible applications within the AAS.

Category

C—NAS Enhancement

Approach

The R,E&D projects described in this chapter will develop automated controller functions, such as clearance generation and delivery, traffic management, and others well beyond AAS implementation. This project will provide the R,E&D support needed to incorporate these new functions, including AERA 3, into the AAS. New conflict alert and resolution functions may also be developed as part of the AAS enhancements.

Because new aircraft types will be entering the system in the future, ATC operations and parameters will change over the longer term. These new aircraft will have different dynamic characteristics, such as faster airspeeds and higher altitudes, that the system must accommodate. Specific modifications to the functional capabilities of the ATC system will be identified so that these aircraft can be fully integrated into the NAS.

Advances in computer technology that may be applicable to the AAS will be investigated. The possible use of computer-aided decision making and expert systems for providing an even higher degree of automation to the planned AAS functions will be examined. Processor improvements, such as parallel and distributed processing, will be evaluated for use in AAS hardware to reduce processing times.

Although the AAS hardware will be designed to be extendable, some hardware modifications may be necessary along the way as the AAS evolves. These hardware modifications will be defined as required.

Products

- Operational requirements and functional specifications for AAS enhancements
- Requirements and specifications for accommodating new aircraft types in the AAS
- Advanced computing technology study reports

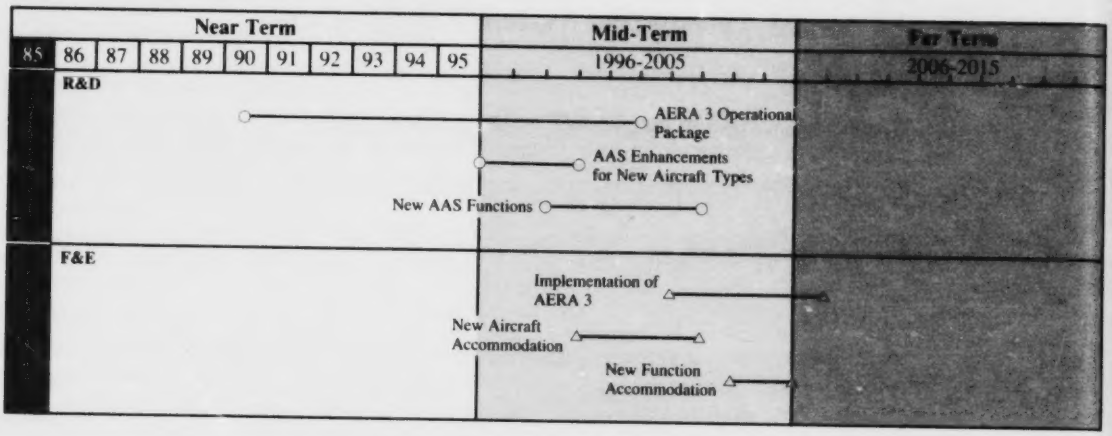
Recent Accomplishments

None

Related Projects/Activities

- Advanced Automation System—must be implemented prior to enhancements development.
- Automated En Route ATC—will develop specifications for AERA 3.
- Airport Surface Traffic Automation—automation functions may be incorporated in AAS enhancement.
- Terminal ATC Automation—automation functions may be incorporated in AAS enhancement.
- Separation Standards—modified and new standards for separation minima will be a driver of the automation software enhancement.
- Advanced Oceanic Automation—will develop oceanic ATC automation, which will be integrated into the enhanced AAS.
- Advanced General Purpose Computer (NASA)—will define a new computer with advanced architecture and device technology features suited to the particular needs of future space systems or other potential users.

Schedule


Near Term
Mid-Term
Far Term
85
86
87
88
89
90
91
92
93
94
95
1996-2005
2006-2015
R&D
AERA 3 Operational Package
AAS Enhancements for New Aircraft Types
New AAS Functions
F&E
Implementation of AERA 3
New Aircraft Accommodation
New Function Accommodation

3.9
Separation Standards

Purpose

To reduce the minimum horizontal separation permissible in CONUS and oceanic airspace, and to reduce the minimum vertical separation permissible above FL290 so as to enhance the overall flexibility and efficiency of the ATC system.

Category

C—NAS Enhancement

Approach

Separation standards in the ATC system are based upon the underlying performance of the communications, navigation, and surveillance (CNS) systems, as well as the ATC automation systems and procedures. Current separation standards in CONUS are consistent with minimum-performance avionics, using the VOR navigation system and the surveillance accuracies and update rates of existing radar systems. Oceanic surveillance currently consists of infrequent pilot position reports. Consequently, oceanic separation standards are based on procedural techniques developed to account for this lack of real-time surveillance data. Tests will be conducted to provide quantitative guidance for reducing separation minima permissible in the ATC system so as to permit the most effective use of new technologies as they are introduced. This effort will also help establish requirements for automatic dependent surveillance and other developing technologies for supporting reduced permissible separation minima.

The oceanic horizontal separation standards program will analyze separation standards in the North Atlantic (NAT), Central East Pacific (CEP), and North Pacific (NOPAC). It will examine the impact of various system improvements on safe minimum widths and longitudinal spacings for oceanic traffic. These improvements will include increased frequency and accuracy of position reports; automatic dependent surveillance; aircraft turn intent and all-digital displays; and new avionics, such as the Traffic Alert and Collision Avoidance System (TCAS). As oceanic traffic becomes increasingly flexible through the automation of ATC, this program will establish appropriate separation standards to facilitate the maximum efficiency and safety of this traffic.

The horizontal separation standards program in CONUS will initially focus on developing new standards for high-altitude airspace. It will also examine the possibility of issuing variable separation standards, with permissible separation minima related to the characteristics of onboard avionics and the ATC environment. Onboard 4D navigation capabilities and ATC capabilities to accommodate 4D navigation will be specifically analyzed in an effort to study the feasibility of time-based separation standards. It must be noted here that separation standards for airport approaches and for areas currently not in radar coverage will be addressed later in separate projects entitled Airport Capacity Improvements and Low-Altitude/Offshore/Remote Area ATC, respectively.

The vertical separation program will examine whether the existing vertical separation minimum above FL290 can be reduced from 2,000 to 1,000 feet with current high levels of safety being maintained. Such a reduction in permissible vertical separation would provide the ATC system with enhanced flexibility to accommodate UPTs and would lead to substantial savings in user costs.

Data will be collected in an effort to determine the height-keeping performance of aircraft above FL290, and to evaluate aircraft certification criteria, aircraft altimeter systems, altimeter certification, and altimeter systems maintenance. Tests will be conducted to assess the safety of reduced separation minima, and also to establish altimetry certification criteria, aircraft equipment requirements, and operational and monitoring procedures. The role of the Global Positioning System (GPS) and the consequent potential for geocentric altimetry and separation standards will also be examined.

Products

Oceanic Airspace

- Report on the feasibility of reduced horizontal separation in oceanic airspace
- Report on simulation and test results for reduced horizontal oceanic separations
- Data package for international coordination on horizontal oceanic separation standards

CONUS

- Recommendations for separation standards for very high-altitude airspace
- Comparative assessment of fixed and variable separation minima
- Evaluation of alternative strategies for incorporation of time-based separation minima

Vertical Separation Standards

- Data analysis, and operational tests and evaluation of reduced vertical separation
- Recommendations for rule making on vertical separation standards

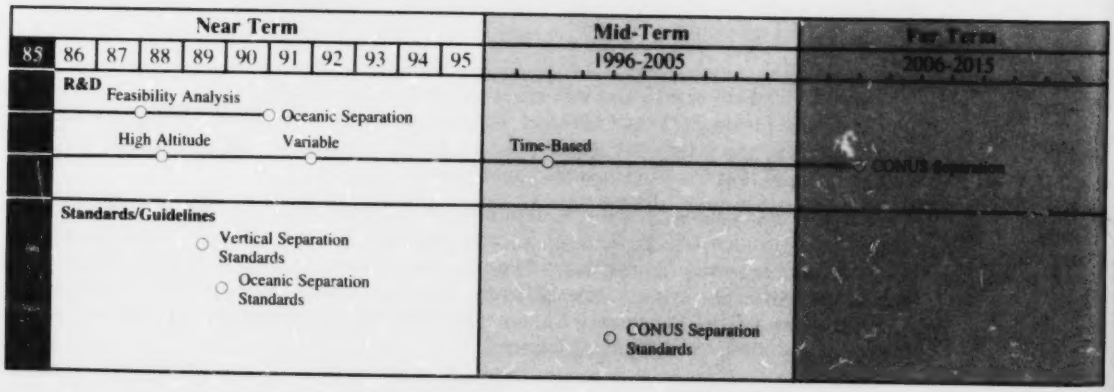
Recent Accomplishments

- Minimum Navigation Performance Standards (MNPS) implemented for an area of the North Atlantic.
- Composite route structure established in Central East Pacific.
- Data collection and analysis performed to confirm proper operations on NOPAC composite routes.
- Composite route in NOPAC implemented.
- Flight tests completed for assessing the practicality and technical feasibility of a technique for data collection to determine 1,000-foot vertical pressure separation above FL290.
- Report on low-altitude VOR-derived route separation produced.
- Data collected on the performance of Altimetry System calibration stations in the U.S.
- OASIS Report on a study of reduced separation standards and improved navigation performance standards produced.

Related Projects/Activities

- Automatic Dependent Surveillance (ADS)—will provide technology for oceanic surveillance.
- ODAPS Enhancements—will determine ADS requirements for the oceanic environment.
- Airport Capacity Improvements—will establish reduced separation standards for approaches to airports.
- Sensor Improvements—all-digital displays and associated higher accuracies necessary from Mode S/Airport Surveillance Radar (ASR)-9 sensors may make possible the reduction of separation standards.

Schedule



3.10
Automated En Route ATC

Purpose

Automated En Route ATC (AERA) will provide interactive software for use by the ACF in planning and monitoring the four-dimensional flow of air traffic. Specifically, AERA will (1) assist the ATC system in permitting most aircraft on IFR flight plans to fly their preferred trajectories in the system, (2) increase the safety of the system by reducing the potential for operational errors, and (3) enhance controller productivity by increasing the number of aircraft and volume of airspace that a control team can safely manage.

Category

B—Direct Support of NAS Plan

Approach

AERA will be developed and implemented in three stages: AERA 1, AERA 2, and AERA 3.

AERA 1 is designed primarily to enable users to fly preferred trajectories, and will be included in the AAS software. It supports probes for predicting potential violations of separation standards, SUAs, and traffic flow restrictions, and for helping supervisors balance sector staffing by providing them with sector workload predictions. AERA 1 will also provide limited conflict resolution aids, reminders, and reconformance aids to controllers.

AERA 2 will extend AERA 1 functions from detecting potential conflicts to providing the controllers with resolutions. It will also introduce the concept of computer-generated, controller-approved clearances for transmission via data link. The conflict resolution algorithms of AERA 2 will be evaluated through simulation of a variety of conflict situations, including multiple aircraft encounters. Controller interface requirements for the conflict resolution function will be developed through simulations with display mockups. These simulations will also identify the information needed by the controller and the information a controller must provide to the system.

AERA 3 will be the final stage of AERA development. It will extend the conflict resolution aid capabilities of AERA 2 to automatic clearance generation and delivery via data link; the specification of automatic backup procedures; and protection of the system from unacceptable failure modes, such as the presentation to controllers of situations that involve an unacceptably high complexity or workload. Initially, in the mid-term, AERA 3 will service suitably equipped aircraft in less densely populated, positively controlled airspaces at very high altitudes. In the far term, AERA 3 will be extended to positively controlled airspaces of greater densities and mixed equipage. AERA 3 will be designed with a view to relieving controllers of the responsibility for time-critical decisions and leaving them with only oversight responsibility. This will enable them to manage a larger volume of airspace than will be possible with earlier AERA stages. Prototype system designs will be evaluated through extensive simulations, as well as failure mode and safety analyses.

Products

- AERA Operational Concept
- AERA 2 functional (A-level) specification
- Report on the AERA 3 concept
- AERA 3 operational description report
- AERA 3 information flow descriptions report
- AERA 3 function-level design
- AERA 3 procedural/equipment requirements
- AERA 3 A-level specification

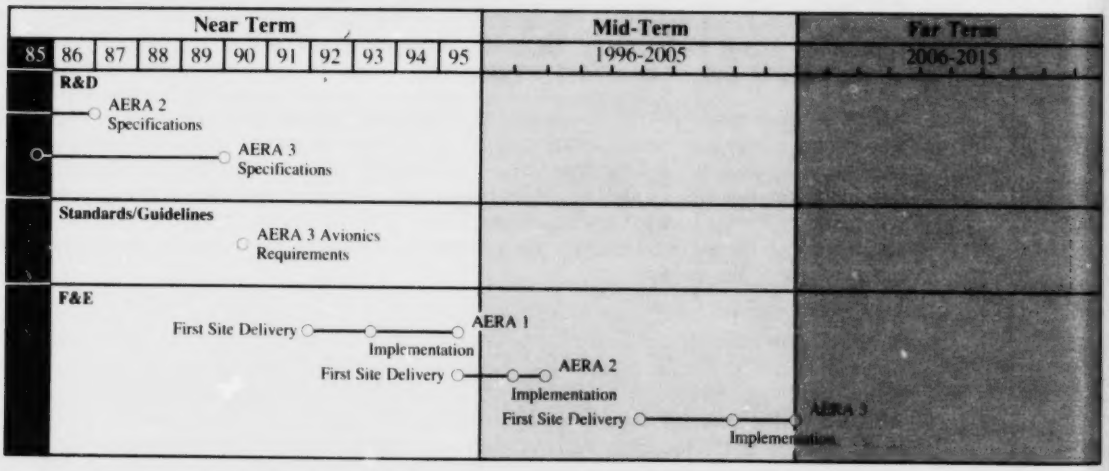
Recent Accomplishments

- Operational descriptions and functional specifications for the AERA 1 functions prepared.
- Proof-of-concept AERA 1 algorithms developed.

Related Projects/Activities

- Advanced Automation System—will conduct operational testing and evaluation of AERA 1 and incorporate AERA 1 functions into the AAS. It will also develop the operational package from the A-level specifications for AERA 2 and incorporate this package into the AAS in the mid-term.
- AAS Enhancements—will develop the operational package from the AERA 3 A-level specifications and implement this package in the mid- and far terms.
- Traffic Management System—will issue traffic management restrictions for compliance by AERA.
- En Route Metering II (NAS Plan)—will develop meter fix and boundary crossing time restrictions for compliance by AERA.
- Weather Processing—will provide accurate wind data and accurate 1-hour weather forecasts.
- Mode S Data Link Applications—Mode S data link, interfaced through the AAS, will provide automated controller/pilot data and advisory interchange.

Schedule



3.11
User-Preferred Trajectories

Purpose

To develop operational procedures and interfaces among ATC system elements, and to develop required automation capabilities that will enable the ATC system to easily accommodate pre- and in-flight requests for user-preferred trajectories (UPTs) with specific airport landing times.

Category

C—NAS Enhancement

Approach

AERA will provide the NAS with the capability to utilize user-specified trajectories with arbitrary route, altitude, and speed profiles. AERA will also enable controllers to estimate the likely success of a user-requested trajectory, and will thus provide a vehicle for the manual accommodation of UPT requests by the ATC system. This project will enhance this capability through automation aids for the accommodation of pre- and in-flight UPT requests. It will develop necessary procedures and standards, including flight plan formats and data link standards for downlinking UPT data, and will establish necessary requirements for AAS processing. The project will also identify necessary interfaces between the AAS, TMS, FSAS, and Mode S sensors, and establish corresponding procedures.

In the mid-term, the enhanced TMS will be capable of accommodating user requests for arrival time windows. Since these arrival times will be requested several hours in advance of the arrival time, the ATC system must have the capability to monitor the flight's progress and ascertain at each point whether the arrival time window is likely to be met. If necessary, the ATC system must then provide for a corrective action, possibly in the form of an ATC advisory. This project will collect the data, conduct the analysis, and develop the design and algorithms required to assess, at any point in flight, whether the arrival times are likely to be met. This project will also develop the coordination with AERA needed to implement the corrective action, if the action needed is a new ATC clearance; for example, certain constraints may be passed to AERA so that AERA may compute a new clearance. The project will develop any new algorithms or automation that may be required to meet time constraints and are not provided by AERA. It will also develop the coordination with enhanced TMS required if it becomes necessary to reschedule previously cleared arrival times. As the arrival time approaches, it is expected that arrival time windows will be narrowed; this project will conduct the analysis and design needed to make possible the computation of these revisions. The project will also develop the design and procedural interfaces with enhanced TMS, Terminal ATC Automation (TATCA), and AERA needed for computing and executing these narrower time windows. In support of these analysis and design activities, this project will gather data on uncertainties in the path and time performance of aircraft as a function of avionics, airspace, winds and weather, user classes and subcategories, traffic densities, traffic demand, and other traffic characteristics and ATC factors. These aircraft performance data will also be used to provide input to AERA, TATCA, and enhanced TMS; this will enhance appropriate related parameters, such as conformance bounds, so that trajectory estimation, time-based clearances, and the assessment of trajectories for future problems can be refined. This project will also conduct necessary research in ATC procedures, and develop automation aids and MMI requirements, to enhance AERA's capability to assess and accommodate UPTs with variable altitude profiles.

Products

- Report on UPT requirements analysis
- Report on impact of mixed equipage
- Functional specifications for continually narrowing UPT time windows
- Operational packages for UPT probes and continually narrowing UPT time windows
- Report on controller MMI requirements and operational procedures for UPT accommodation

- Reports on the requirements for interface and coordination with TMS, Traffic Management with Arrival Time Accommodation, 4D Navigation in ATC, Dynamic Special Use Airspace Management, and FSAS
- Report on AAS requirements
- Report on special UPT requirements in the oceanic airspace and in low-altitude, offshore, and remote areas

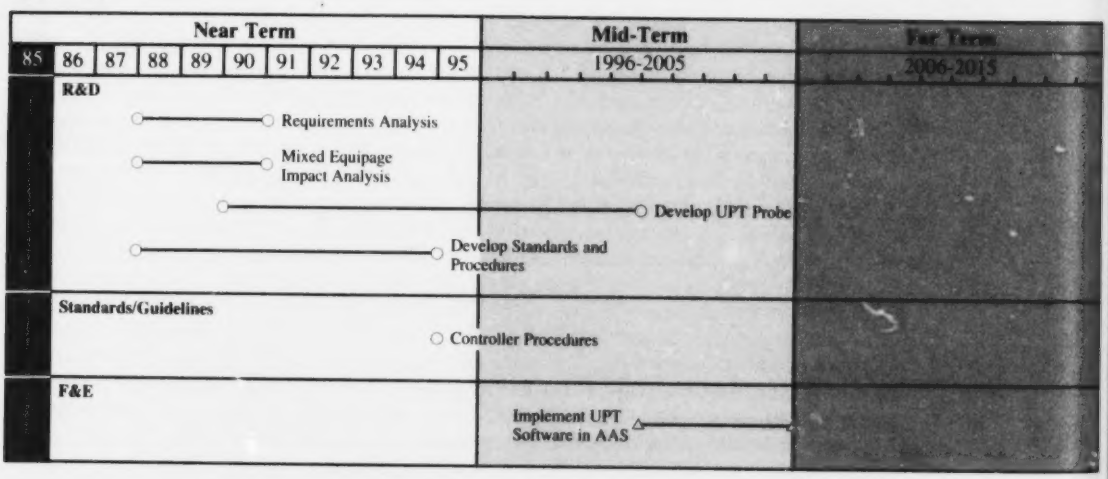
Recent Accomplishments

None

Related Projects/Activities

- Traffic Management with Arrival Time Accommodation—will provide the capability for accommodating user requests for airport landing times.
- 4D Navigation in ATC—will provide the capability to accept 4D profiles.
- Automated En Route ATC—will provide database structures and initial capability to accommodate UPTs.
- Weather Processing—will provide the better winds and weather information required to enhance time and trajectory estimates by aircraft and ATC.
- Flight Service Automation System, Advanced Automation System, and Mode S Data Link Applications—will provide mechanisms for feedback and accommodation of UPT requests.
- Dynamic Special Use Airspace Management—will provide timely and accurate information on special use airspace.

Schedule



3.12
4D Navigation in ATC

Purpose

To investigate the incorporation of time as a basic parameter in the ATC system, allowing 4D navigation-equipped aircraft to fully utilize the capabilities of their onboard avionics.

Category

E—New Initiatives

Approach

The use of time as an independent parameter in the ATC system may allow 4D navigation-equipped aircraft to request and meet specific arrival times at airports and meter fixes, thus optimizing their flight paths with respect to time and fuel. The ATC system uses spatial coordinates as the basis for flight monitoring and control to ensure the safe separation of aircraft. Time is used in the planning of departures and arrivals, but not in flight plan filing and tactical control.

This project will investigate the basic problem of incorporating time as an independent parameter in the ATC system with reference to the impact on flight services, pilot/controller communications and workload, controller procedures, and avionics requirements. Potential benefits in the form of pilot and controller workload reductions, airport and en route capacity increases, and fuel savings will be examined. Alternate concepts for the control of time-navigation aircraft will be defined, and the effects on the ATC system will be assessed.

Initially, specific procedures and software will be developed that will allow aircraft equipped with 4D navigation to meet ERM-assigned times by adjusting their speed profiles. The impact of aircraft equipage mix on pilot and controller workload will be evaluated in the ERM environment.

Products

- Development of pilot/controller time navigation procedures for use with ERM II
- Pilot/controller time navigation procedural analysis and requirements report
- Report on controller and pilot man/machine interface requirements for time navigation
- Report describing changes to FAA standards and procedures for accommodating 4D navigation
- Report on requirements on existing and developmental automation systems for incorporating time navigation

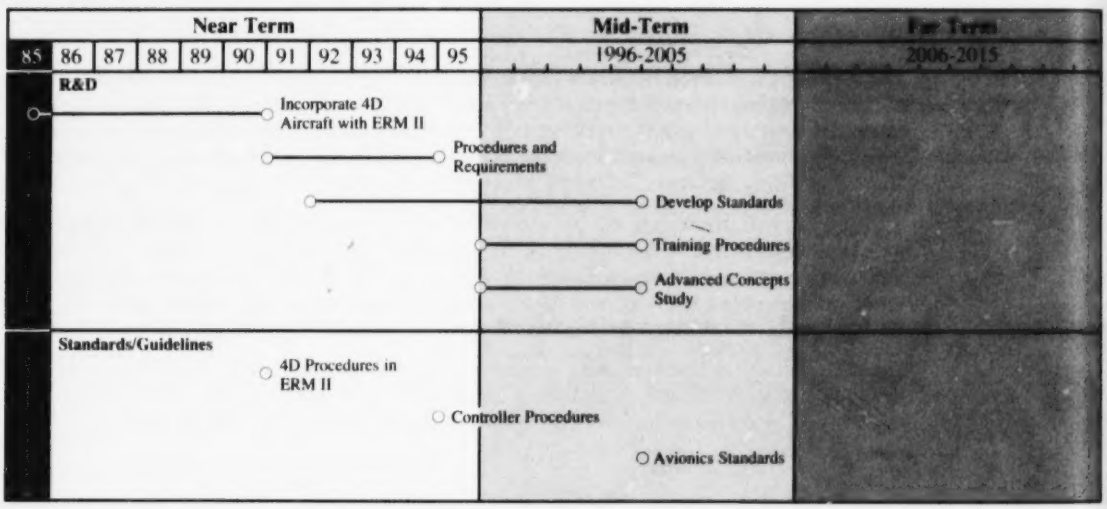
Recent Accomplishments

None

Related Projects/Activities

- En Route Metering II (NAS Plan)—ERM II provides the meter fix or boundary crossing time restrictions, and could identify 4D-equipped aircraft to the sector controllers.
- Automated En Route ATC—will require each 4D-equipped aircraft to provide its trajectory for meeting the 4D restrictions.
- Mode S Data Link Applications Development—Mode S provides the capabilities to downlink 4D trajectories or uplink 4D restrictions, such as ERM II meter fix or boundary crossing times.
- Avionics Certification R,E&D—will develop guidelines for avionics designs.

Schedule



3.13
Area Control Facility Backup

Purpose

To ensure continued control and monitoring of aircraft in the event of the sudden or catastrophic failure of an Area Control Facility (ACF).

Category

C—NAS Enhancement

Approach

The ATC system is required to provide control and separation services within its jurisdictional airspace at all times. Although the likelihood of total failure of an ATC facility is very low, such failures have occurred in the past and may occur again. Provisions must therefore be made for uninterrupted communication with and control of the aircraft within the failed airspace. A concept for ACF backup has been developed that envisions adjacent ACFs assuming the control and monitoring responsibilities of the failing ACF. This project will develop the ATC procedures and define controller aid requirements for implementing such a backup system. In addition, site-specific backup requirements will be developed for the facilities at Anchorage and Hawaii because of their special needs for oceanic traffic.

Assumption of control of a failed ACF's airspace will be very stressful for the controller. Suitably designed automation tools would be of great value to controllers in easing the transition to backup. Therefore, various possible controller aids, from simple modifications of the normal flight data displays to the implementation of an expert system that would assist in reconfiguration of the backup facility, will be investigated and verified through simulations.

With increasing levels of automation, ATC procedures and the controllers' role may be vastly different in the future. When AERA 3 is in place, for example, each controller may handle many more aircraft than is the case today; in the event of an ACF failure, the workload of controllers will be significantly higher. The impact of such a changing environment on the strategy for providing a backup will be examined through analyses and simulations.

Products

- Procedures and requirements specification for special controller aids for ACF backup
- Report on the design of facility backup for non-CONUS facilities
- Demonstration of use of expert systems for facility reconfiguration
- Functional specifications for the use of AERA 3 capabilities in facility backup
- Operational and functional specification for backup automation for controllers in the AERA 3 time frame

Recent Accomplishments

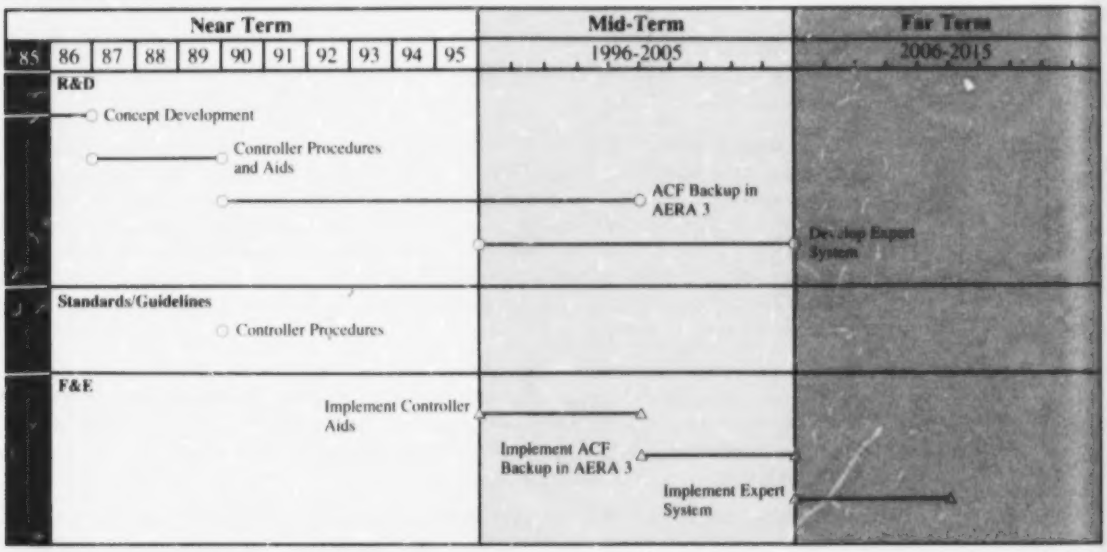
- ACF backup concept developed.
- Preliminary scenario used to illustrate the concept of using ACFs adjacent to the failed facility as backup.
- Communication and processing needs of providing ACF backup examined.

Related Projects/Activities

- Advanced Automation System—ACF backup will be implemented within the AAS.
- Area Control Facilities (NAS Plan)—consolidation of radar control facilities will determine the backup strategy.
- National Airspace Data Interchange Network II—will provide the communications network for backup systems.
- Voice Switching and Control System—the backup voice system will be VSCS for interfacility switching.

- Automated En Route ATC—AERA MMI and automation aids will be examined for use by controllers for ACF backup.
- Mode S Data Link Applications Development—will provide the capabilities for automatic uplink of clearances, possibly including backup clearances in the AERA 3 time frame.
- Traffic Management System—will define national restrictions and reroutes that would minimize the impact of the failed ACF on the ACFs that are assuming control responsibility.

Schedule



3.14
Low-Altitude/Offshore/Remote Area ATC

Purpose

To provide urgently needed separation services to rotorcraft and fixed-wing aircraft, initially in certain low-altitude and urban areas; to develop an all-weather ATC service, integrated and comparable to the NAS, for all low-altitude, offshore, and remote areas; to provide the basis for low-altitude direct routings.

Category

C—NAS Enhancement

Approach

This project will develop the functional and operational requirements of CNS systems, as well as aircraft and ATC procedures, that will facilitate improved operations, routes, and airspace design in these areas. Specific activities in the initial phase of this project will include the following:

- Collection of flight technical error data—A series of flight tests will be conducted using representative second- and third-generation helicopters with various navaids. The resulting data will be used to develop the criteria for terminal instrument procedures (TERPS) for rotorcraft approach and landing operations.
- Resolution of several helicopter-related ATC problems—Current ATC separation standards for helicopters are extremely conservative, calling for larger vehicle separation because of the lack of adequate data on wake vortex and downwash. Data are being collected for characterizing wake vortex and downwash so that separation minima can be reduced. Such a reduction will result in improved fuel efficiency for helicopters, and increased capacity of the terminal airspace used by helicopters and fixed-wing aircraft. Terminal and city-center-to-city-center route designs and procedures, along with related separation criteria, will be reviewed to determine if the ATC system can be improved for fuller integration of rotorcraft into the NAS. Specialized procedures for the use of dependent surveillance systems in selected parts of the NAS will also be developed.
- CNS system requirements—Current and projected low-altitude requirements for these services will be defined by a consideration of flight operations and ATC factors, and by a review of the results of technical studies conducted under related projects, such as LOFF.
- Cost-benefit analysis—Various options for service improvement will be evaluated on the basis of cost-benefit analysis in an effort to identify preferred options for NAS implementation. These studies will also identify specific geographic areas with the greatest need for low-altitude service.

In its second phase, this project will develop the operational ATC concepts and the implied CNS and controller display requirements for a more general ATC service, integrated and comparable to the NAS, for all low-altitude, offshore, and remote areas. It will examine the unique and improved capabilities of new aircraft types expected to appear in this airspace, and establish specific future ATC requirements for rotorcraft, such as the capability to accommodate direct random low-altitude routes in these areas. Separation standards for low-altitude/offshore/remote areas will also be modified, if required.

Products

- NAS requirements for low-altitude CNS
- Low-altitude ATC automation for selected areas in the NAS
- Modified separation standards for rotorcraft
- Rotorcraft TERPS criteria
- Low-altitude, offshore, remote area ATC concept for full integration into the NAS (CNS requirements; functional operational specifications and interface documents; controller display requirements; procedures and avionics requirements, including ATC requirements for flight inspection)
- Reports on analyses of rotorcraft flight operations procedures

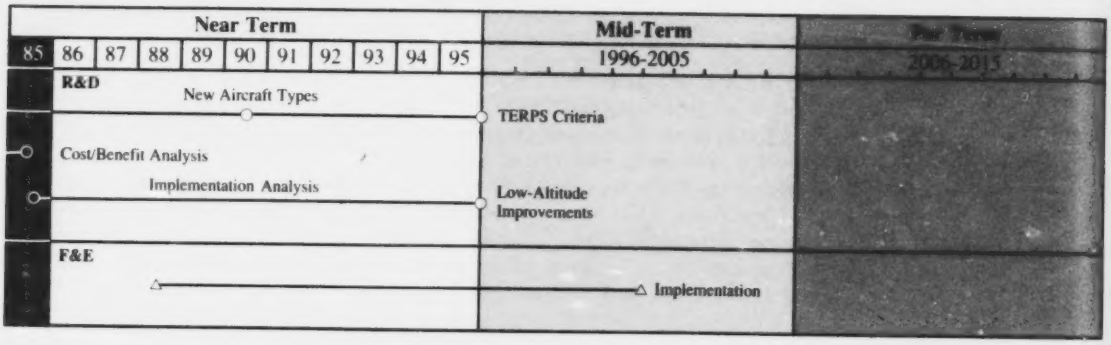
Recent Accomplishments

None

Related Projects/Activities

- Low-Altitude Surveillance—will furnish the surveillance needed to satisfy the needs of low-altitude, offshore, and remote areas.
- Rotorcraft Master Plan (FAA)—provides the overall plan for rotorcraft operation up to the year 2000.
- Rotorcraft Communications—will provide enhanced rotorcraft communications.
- Precision Approach and Landing—provides initial capabilities for flexibility to integrate rotorcraft and other special-application aircraft into the NAS.
- Helicopter Modeling and Flight Test Data Requirements—will make possible rapid simulation and analysis capabilities.

Schedule



3.15
Terminal Enhancements

Purpose

To provide development and support for the Automated Radar Terminal System (ARTS) to ensure that its availability, reliability, and capacity remain acceptable as demand increases. Hardware and software modifications will be developed for enhanced automation functions and for interfaces to new ATC systems, such as Mode S data link.

Category

C - NAS Enhancement

Approach

ARTS will continue to provide the computer resources for terminal area ATC until replaced by the AAS and the consolidated ACFs. Increased demand for airspace usage and requirements for additional automation functions in the terminal area will necessitate a large sustaining effort to keep ARTS in use, particularly at the New York Terminal Radar Approach Control Facility (TRACON), which is nearing saturation.

Terminal automation functional enhancements will refine terminal conflict alert algorithms and logic to reduce the nuisance alarm rate, and to extend coverage to terminal airspace areas that are now desensitized within the current conflict alert function. In particular, the enhancements will optimize processing algorithms to minimize computer resource requirements, and will reduce radar position uncertainties due to radar registration error, alignment inaccuracy, and position coordinate conversion.

New sensor data will be available to ARTS when Mode S is implemented in the terminal environment. Appropriate interfaces and software modifications needed to utilize the Mode S sensor data will be developed.

Products

- Specifications for hardware improvements needed to sustain ARTS
- Implementation package for Terminal Conflict Alert enhancement
- Mode S sensor interface requirements

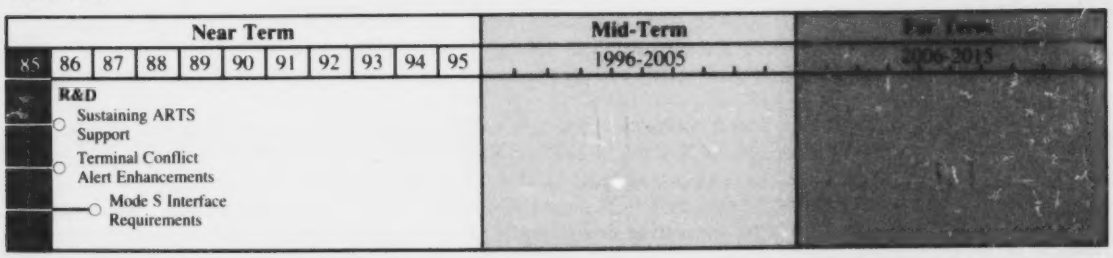
Recent Accomplishments

- Report on the analysis of ARTS III Terminal Conflict Alert Nuisance Alarms published.

Related Projects/Activities

None

Schedule



3.16
Terminal ATC Automation

Purpose

To develop a terminal planning and advisory aid for controllers so that the utilization of available terminal capacity can be maximized through sequencing and scheduling of the aircraft on flexible arrival and departure routes.

Category

E—New Initiatives

Approach

Automation of aircraft sequencing and scheduling in the terminal airspace was found to be difficult in the past for several technical reasons, including, among others, inadequate controller interface with automation, lack of accurate winds aloft data, and lack of accurate demand predictions. The critical technical problems are expected to be alleviated in the near term. This project will therefore reexamine the status of weather prediction, avionics, and other related technologies, and identify operational, functional, and technical requirements for terminal ATC automation (TATCA). TATCA will represent a major development effort, and will be accomplished by development of the following specific functions:

- Dynamic Arrival and Departure Planning—This function will provide to ERM II and the TMS dynamic 1- to 2-hour updates of expected airport capacity in terms of aircraft acceptance rate based on expected traffic and runway conditions. Besides the environmental factors affecting runway use, airport capacity is a function of the runway condition and configuration in use, departing traffic, interarrival spacings between aircraft mixes, runway occupancy times, and the accuracy of the estimation of aircraft arrival times. Established separation standards can be used to define the theoretical capacity of an airport for an expected sequence of aircraft under IFR weather conditions. For aircraft on IFR or VFR flight plans landing at airports with visual meteorological conditions (VMC), airport capacity is generally increased as a result of reduced permissible vehicle separation. Although it may be difficult to define airport capacity uniquely under such conditions, it will be possible to estimate potential acceptance rates for a known sequence of aircraft. Actual operating data related to current IFR/VMC operations will be analyzed in an effort to formulate a method of predicting aircraft acceptance rates under such conditions. Automatic assignment of aircraft to runways will be provided for maximizing runway throughput. This function will be expanded later for application to multiple-airport complexes with dependent runway configurations.
- Airspace Allocation—This function will accommodate flexible arrival and departure routes in the terminal area for most direct access and egress for any given runway configuration. Arrival and departure flows may be separated through the use of azimuthal arrival and departure corridors and special segregated corridors for rotorcraft. Appropriate procedures will be developed so that specific arrival routes may be assigned to aircraft before their entry into the terminal area.
- Sequencing and Scheduling—A data base of optimum aircraft performance characteristics and appropriate algorithms will be developed for computing accurate flight times for any given aircraft type and any constraints, such as minimum fuel or time. This data base will then be used to provide sequences and schedules (i.e., accurate times of aircraft arrivals at the terminal entry fixes) to the time-based ERM function in the mid-term. Properly equipped aircraft will downlink accurate trajectories to the ATC system as required.
- Automated Speed Advisories and Limited Vectoring Advisories—These will also be provided to controllers for sequencing and spacing aircraft on their assigned routes in the terminal area. Clearances will be transmitted to equipped aircraft via data link. Manual quasi-4D clearances will be provided to unequipped aircraft so that they can meet their ERM times. These algorithms will be fully integrated with separation assurance algorithms to ensure the operational viability of such advisories. Procedures will also be developed, especially for VFR aircraft, for entering and operating within such an automated terminal area.
- Clearances at High-Density Airports—In the far term, these will be automatically generated and transmitted to the aircraft. Aircraft not equipped with data link may receive automatically generated voice commands.

Minimum equipage requirements, if any, will be identified, and the total system will be designed for effective integration of the aircraft population with mixed equipage.

Products

- Specification for an automation aid for the design of flexible arrival/departure routes
- Operational concept of terminal ATC automation for enhancing terminal-area capacity
- System specification for automatic runway assignment of aircraft
- Algorithm for short-term (1 to 2 hours) computation of airport capacity and acceptance rate
- Functional and operational descriptions for the provision of sequences and schedules to the ERM function
- Functional and operational specifications for the generation of sequencing and spacing advisories
- Functional and operational specifications for the automatic generation and delivery of sequencing and spacing clearances
- Equipage and procedural requirements for accommodation of 4D- equipped aircraft
- Alternatives analysis of automatic voice generation integration

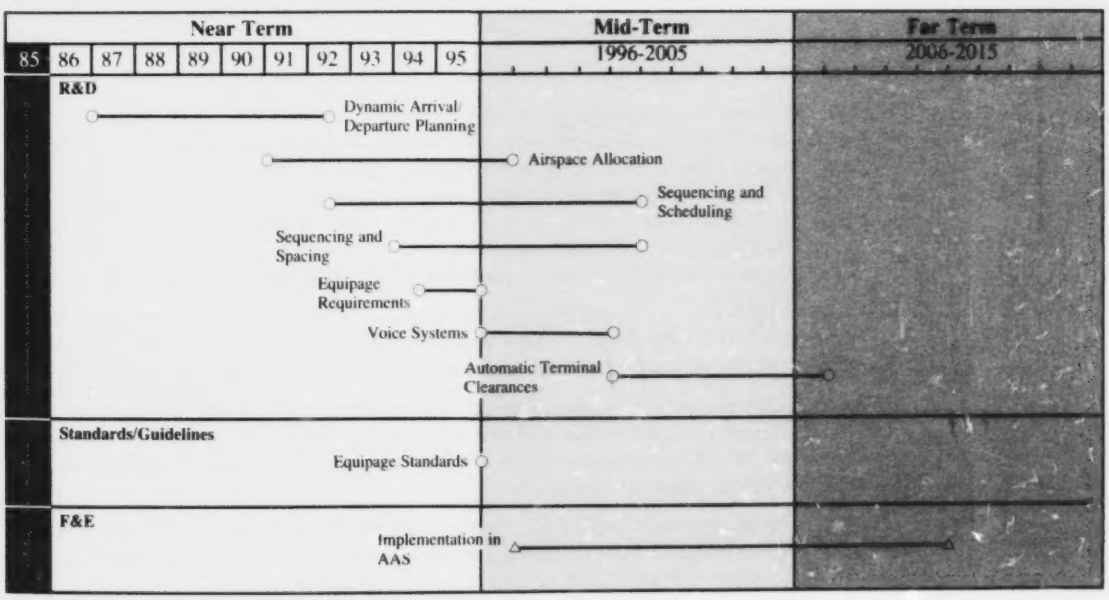
Recent Accomplishments

None

Related Projects/Activities

- TMS's Runway Configuration Management System—will provide TATCA with information on the current and expected runway configuration in use.
- En Route Metering II (NAS Plan)—will provide TATCA with information on arriving and departing aircraft well in advance for establishing tentative sequences and schedules.
- Weather Processing—will provide one-hour forecasts of severe weather and winds for the terminal area; also forecasts of expected major changes in runway meteorological condition, and even minor changes if near Instrument Meteorological Conditions.
- Precision Approach and Landing—will facilitate flexible route structures in the terminal area.
- Mode S Data Link Applications Development—will provide for automatic clearance delivery in the far term.

Schedule



3.17
Airport Capacity Improvements

Purpose

To identify technical requirements for increasing airport capacity under all weather conditions through the use of multiple instrument approaches and departures. This project will also identify any changes or improvements in navigation and surveillance systems that would be needed to support these procedures for improving airport capacity.

Category

C—NAS Enhancement

Approach

Recent studies sponsored by the FAA and the aviation industry have identified a set of operational concepts that could increase airport capacity and reduce delays. These concepts include the following:

- Independent parallel IFR approaches at runways with centerline spacings of as low as 3,000 feet
- Converging (nonparallel) IFR approaches
- Triple independent and dependent IFR approaches
- Operational solutions to avoiding wake vortex hazards
- The use of separate short runways and off-runway heliports to take advantage of specialized aircraft, such as the DH-7 and rotorcraft

This project will develop appropriate procedures and define avionics requirements for implementing the above concepts. The impact of various factors, such as runway occupancy time and aircraft performance, will be assessed. Wider applicability of these procedures through the use of the Microwave Landing System (MLS) and advanced onboard avionics will be studied. The use of MLS for reducing obstacle clearance envelopes specified in the Terminal Instrument Procedures (TERPS) will be examined. Another project (Precision Approach and Landing) will develop operational procedures using MLS to improve airport capacity. Modifications of controller display information, such as expanded lateral scale, will also be developed.

Accurate monitoring of runway approaches using a supplemental terminal radar is currently considered necessary to support independent closely spaced parallel (3000-foot separation) and converging operations. The need for such monitoring, as well as possible alternative approaches, including certain MLS procedures, will be evaluated. An independent project is evaluating alternatives for a low-cost landing monitor.

The use of approaches to converging runways provides a high payback in capacity. Control procedures must be developed that will provide adequate separation assurance and allow the widest applicability. The use of these procedures during periods of reduced visibility may require modifications to the ATC sensor systems to provide continuous coverage throughout the approach and missed approach phases. Many of the applications of converging approaches will involve the use of separate short runways. Procedures for allowing IFR/IMC approaches to separate short converging runways may require the use of improved surveillance and advanced avionics to take advantage of the higher maneuverability of slower-moving aircraft.

The hazards of wake vortices are the major inhibitors of increased runway capacity. The increased precision and flexibility of the MLS may allow multiple approach paths that avoid each others' vortex hazards. Procedures must be developed that will provide separation assurance while taking advantage of this capability of MLS.

Triple approaches are currently used at some airports when visual conditions are three miles or better. The development of IFR procedures that will permit triple approaches during periods of reduced visibility requires an investigation of appropriate surveillance and navigation systems that will ensure separation during the approach and missed approach phases.

In the longer term, approach and landing procedures and related separation standards will be modified, if necessary, in response to such technological advances as forecasting and avoidance of wake vortices, and Cockpit Display of Traffic Information (CDTI) applications.

In the near-term period from 1985 to 1987, procedures will be evaluated that do not require advanced surveillance or navigation systems. Beyond 1987, advanced surveillance and navigation systems will be incorporated into the procedures. For each procedure involving multiple instrument approaches, field testing will be performed to demonstrate the operational suitability of the procedures, and to provide the basis for the development of appropriate standards.

A separate study will be conducted to investigate methods for reducing runway occupancy time, a major bottleneck in the system. Both newer and older ideas of drift-off runways, elongated exits, dual-lane runways, and multiple runway occupancy will be examined in light of current technology.

Products

- Procedures to accommodate multiple instrument approaches
- Sensor and navigation requirements to support multiple instrument approach procedures
- Results of field testing of multiple instrument approaches
- Concepts for reducing runway occupancy times

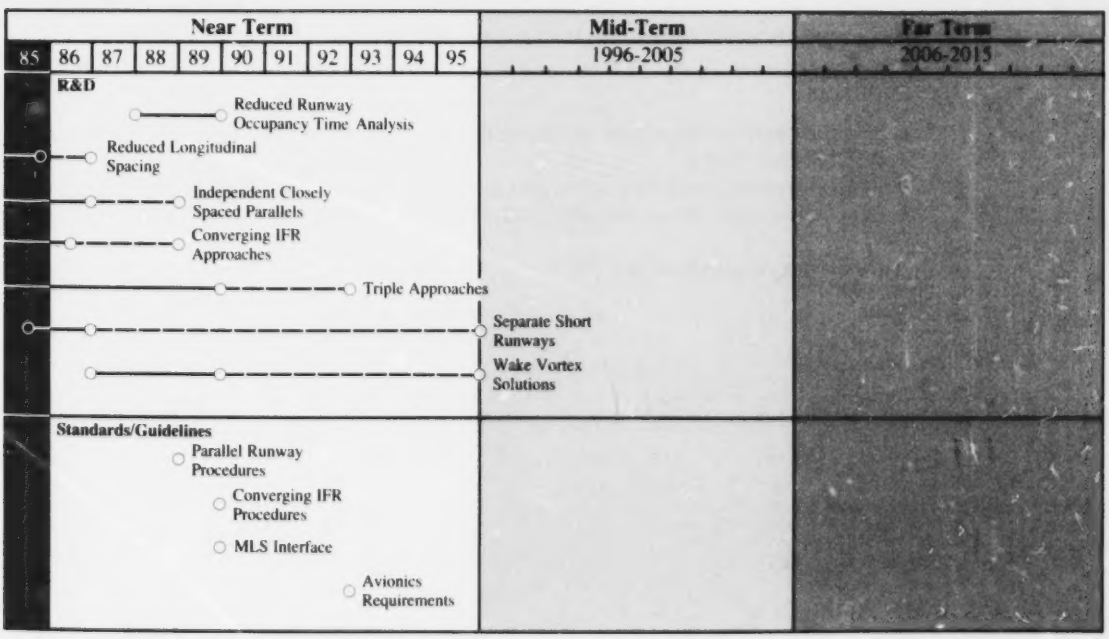
Recent Accomplishments

- Preliminary standards for closely spaced parallel approaches developed for operational evaluation.
- Operational standards for converging approaches prepared and evaluated.
- Converging approaches being used at Chicago O'Hare.
- MLS TERPS obstacle clearance envelopes being modified.

Related Projects/Activities

- Landing Monitor for Closely Spaced Runways—can provide monitoring support for closely spaced parallel approaches.
- Precision Approach and Landing—MLS curved and variable glide slope capabilities will be investigated for their application to wake vortex avoidance procedures, parallel and converging approaches to reduced minima, and missed approach procedures.

Schedule



3.18
Airport Surface Traffic Automation

Purpose

To provide automation assistance to the controller in maximizing runway/taxiway/apron/gate efficiency and airport capacity in all weather conditions; to provide airport surface separation assurance, especially during low-visibility conditions, by providing an automated taxiway/runway intersection control function based on the use of improved airport surface surveillance and communications systems.

Category

E - New Initiatives

Approach

Operations of aircraft and other ground vehicles on the airport surface will be analyzed in detail as a first step in identifying the functional requirements of an airport surface guidance system. Airport Surface Traffic Automation (ASTA) will then be developed as a tower controller's automation aid for safely and efficiently organizing and routing aircraft between gates and runways to maximize airport capacity. A ground surveillance system, such as enhanced Airport Surface Detection Equipment (ASDE), will be utilized by ASTA to aid controllers in monitoring aircraft and other ground vehicles on the airport surface. This project will identify the functional requirements for utilizing airport surface surveillance data, integrated with controller-defined routings, to guide aircraft through any runway or taxiway intersection safely and efficiently. Algorithms that utilize these surveillance data and controller routings will be developed for probing and resolving potential airport surface conflicts by generating go/no-go indicators for the vehicles predicted to be in conflict. ASTA will identify and evaluate go/no-go indication alternatives, such as intersection lighting, vehicle displays, and controller alerts. The conflict prediction algorithms will be tested and evaluated through traffic simulations. VHF radio and Mode S data link will be used for communications between the tower and vehicles. The use of data link for the transmission of airport surface traffic routing control and go/no-go commands will be evaluated as part of this project. In addition, minimum surveillance and communications coverage and surveillance update/accuracy requirements will be defined toward the eventual evolution of ASTA as a system for completely automatic ground traffic management under all weather conditions.

Products

- Specifications for automated prediction of potential conflicts on airport surface using integrated ASDE/Mode S data
- Functional specification for an airport surface guidance system managed by tower controllers
- Functional requirements and specifications for all-weather automatic airport surface guidance system

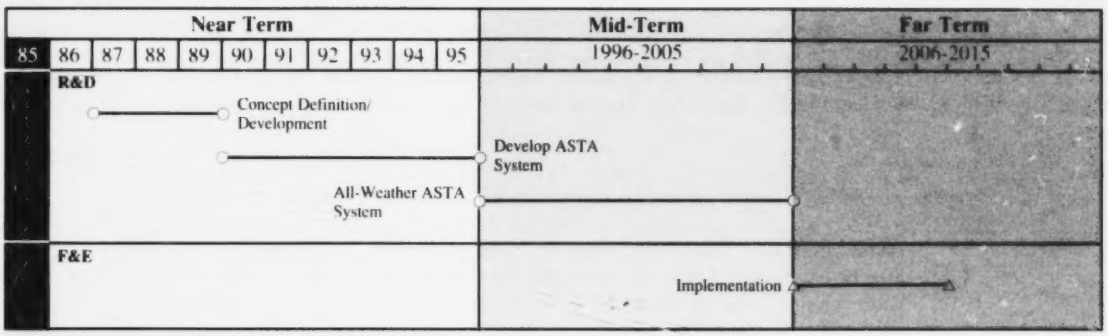
Recent Accomplishments

None

Related Projects/Activities

- Airport Surface Surveillance—will provide the capability for associating alphanumeric data with targets, prior to the integration of ASDE with Mode S data; will also provide initial use of data link communications on the airport surface.
- All-Weather Taxiway Guidance—will develop the operational system for runway/taxiway lighting and navigation based on the functional requirements provided by ASTA.
- Traffic Management System—The Runway Configuration Management System (RCMS) of the TMS will provide ASTA with the identification of current and expected runway configurations for use in surface traffic planning and control from runways to gates.
- Terminal ATC Automation—will subsume the Departure Flow Metering (DFM) capabilities of the TMS in the future and will provide runway departure schedules to ASTA.

Schedule



3.19
Oceanic Display and Planning System Enhancements

Purpose

To provide controllers with a situation display of current aircraft position based on flight plans and associated aircraft position reports, using automatic dependent or independent surveillance; to adapt controller displays for the monitoring of aircraft separation.

Category

C - NAS Enhancement

Approach

The FAA is currently developing the Oceanic Display and Planning System (ODAPS) for providing controllers with automated flight plan processing, flight plan conflict probe, and a situation display based on extrapolated flight plan positions as corrected by hourly position reports. ODAPS will thus be primarily a planning and display system. The AAS is being designed to provide oceanic functions, and will replace ODAPS in the mid-1990s.

This project will develop oceanic ATC capabilities significantly beyond ODAPS. As a first step in this development, the operational and functional requirements of oceanic ATC as specified in the AAS and ODAPS will be reviewed, specifically in relation to technological advances projected in the areas of surveillance and communications. The status of the LOFF surveillance system under development for offshore applications will also be examined. Alternate strategies for dependent, cooperative, and independent automatic surveillance will be developed. Backup strategies using TCAS derived surveillance data, dual surveillance systems, and other methods will also be examined. Requirements for oceanic automatic dependent surveillance (ADS) will be established through an examination of its feasibility; potential benefits, such as system capacity, flexibility, controller productivity, and fuel savings; and system costs. Controller display and aircraft surveillance requirements for monitoring vehicle separation will also be developed. Possible improvements, such as the display of real-time weather data, 4D trajectories, and flexible routes, will also be evaluated. Finally, alternate concepts for an oceanic controller workstation will be developed and evaluated.

Products

- Comparative evaluation of alternate strategies for automatic surveillance
- Report on oceanic ADS requirements
- Functional requirements and operational procedures for displays used in monitoring separation
- Functional specifications and design guidelines for controller workstations
- Prototype controller workstations

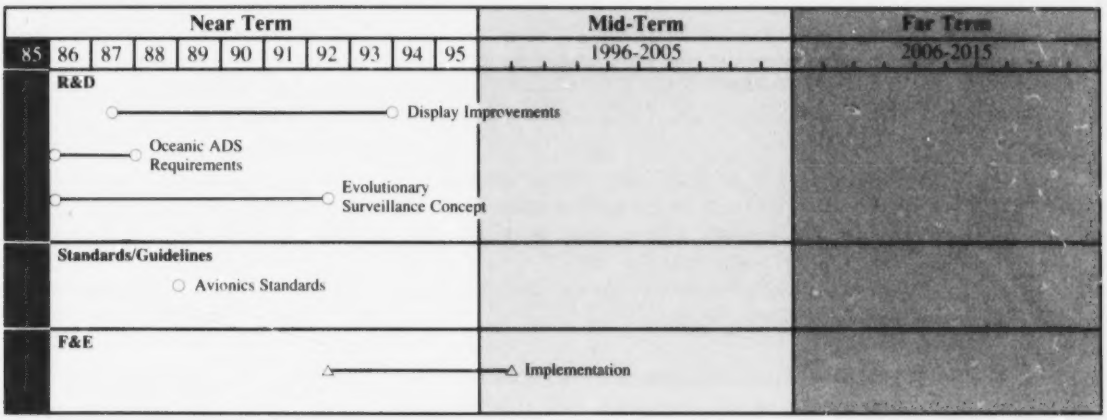
Recent Accomplishments

None

Related Projects/Activities

- Automatic Dependent Surveillance—will develop the ADS technology.
- Separation Standards—will develop oceanic separation standards.
- Low-Altitude Surveillance—will provide surveillance coverage in low-altitude/offshore airspace.

Schedule



3.20
Advanced Oceanic Automation

Purpose

To improve controller productivity and to accommodate user-preferred trajectories (UPTs) through the use of automation aids, such as flight plan conflict probe and resolution, oceanic metering, and others.

Category

E—New Initiatives

Approach

Concepts for flight plan conflict probe and resolution will be developed and evaluated. These concepts are expected to evolve from manual coordination to automatic transmission of computer-generated clearances to aircraft via data link. These evolutionary steps will be clearly defined. Specific modifications to the trajectory-modeling software of AERA will be defined toward its use in oceanic airspace for flight clearance planning and tactical control. The operational coordination between oceanic automation and oceanic traffic management that will be necessary for facilitating UPTs will be developed; the interfaces between these two systems will also be identified.

This project will also address the feasibility of using HF, VHF, or satellite data link for the automatic transmission of ATC messages, such as altitude confirmation, clearances, sector handoff, and handoff frequencies. The functional requirements for such a data link will also be developed through the definition of polling strategies, message content, message transfer and backup concepts, and the like. Specific planning aids, such as automated aircraft sequencing and scheduling, delay absorption advisories to controllers, an interface with domestic metering, and the acceptance of oceanic traffic management restrictions, will be developed toward automating oceanic metering. The feasibility of utilizing aircraft 4D capabilities to meet metering schedules will also be examined. In the final stage of oceanic automation, functional and operational requirements will be developed for the automatic generation of ATC clearances in oceanic airspace.

The conflict probe, trajectory modeling, and other software developed under this project will be evaluated with the help of oceanic traffic simulations.

Products

- Functional and operational specifications for conflict probe and resolution enhancements
- Prototype software for laboratory evaluation
- Requirements for trajectory modeling in the oceanic environment
- Data link requirements for oceanic operations
- Operational and functional requirements for the automatic generation and transmission of clearances
- Requirements for operational coordination and interface between oceanic automation and oceanic traffic management

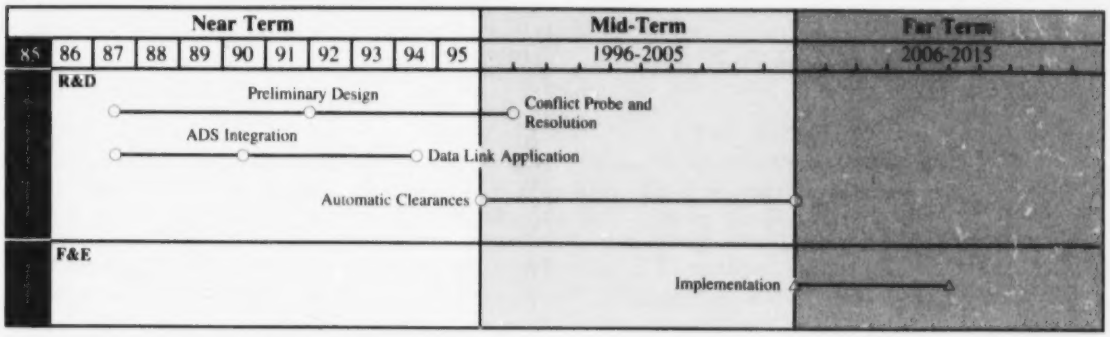
Recent Accomplishments

None

Related Projects/Activities

- Automated En Route ATC—basic algorithms for automatic conflict probe resolution and clearance transmission in high-altitude domestic airspace developed under AREA 3 will be modified for oceanic applications.
- HF/ARINC Communications Addressing and Reporting System (ACARS)—may provide ADS in the near term.

Schedule



3.21
System Performance Monitoring and Assessment

Purpose

To develop requirements for monitoring and assessing the performance of elements of the ATC automation system and supporting systems, such as CNS; to develop an organizational structure and related procedures for quickly correcting any ATC system deficiencies thus identified.

Category

D—Sustaining R,E&D Activities

Approach

A survey of the state-of-the-art methods for monitoring and assessing the performance of large complex systems like the ATC system will be conducted. System-wide variables, such as safety, capacity, hardware and software reliability, and functional performance, will be used as broad performance indices. A comparative evaluation of hardware-based, software-dependent, manual, and interactive techniques of performance monitoring will be undertaken. Specific techniques will be identified for use during the development and design of new ATC system elements, as well as for use during the deployment of existing and new elements.

This project will also include a survey of all existing performance- and safety-monitoring activities, such as the NASA Aviation Safety Reporting System (ASRS), the incident reporting system, service outage reports compiled by the FAA's Airways Facilities, the system delay and outage reports compiled daily as part of the National Airspace Performance Reporting System (NAPRS), and Executive Committee (EXCOM) briefings. The purpose of this survey will be to examine these activities for specific application to different elements of the ATC automation system. Additional indices will then be defined for assessing the performance of individual elements of the system; these indices would include, for example, productivity and safety for AERA 3, ground and air delays for TMS, and accepted-to-total ratio of user requests for UPTs. These and other appropriate indices will be identified and ranked. Requirements for the number and frequency of observations for online performance monitoring will also be established.

An organizational structure and related procedures will then be developed for evaluating the performance data thus monitored, and for identifying and correcting any system deficiencies in a timely manner.

Products

- A handbook for monitoring and assessing the performance of FAA systems
- Safety and system performance analysis procedures/guidelines for the FAA R,E&D projects
- Recommended performance indices and requirements for built-in real-time performance-monitoring systems, defined separately for the AAS, TMS, UPTs, AERA, TCAS, and others
- Definition of an effective organizational structure for monitoring and assessing ATC system performance
- Methodology of performance analysis for the NAS Plan

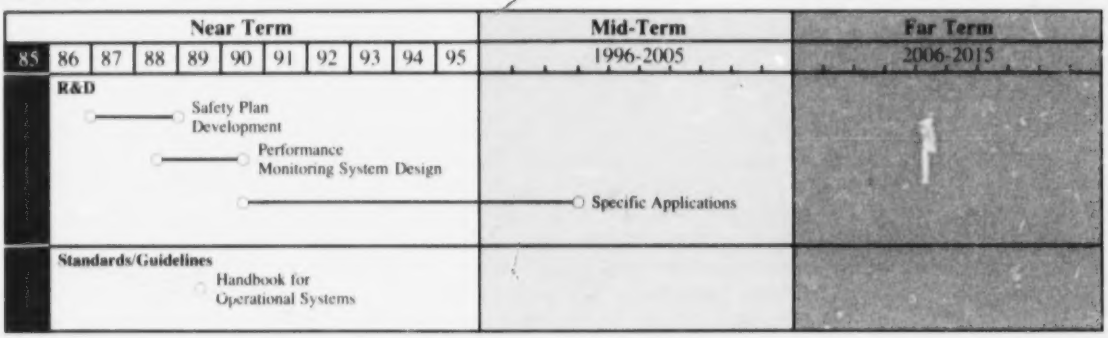
Recent Accomplishments

None

Related Projects/Activities

None

Schedule



3.22
Aviation Fuel Conservation

Purpose

To develop basic concepts, algorithms, and related ATC procedures that will facilitate aircraft operations with minimum fuel consumption within the NAS.

Category

C - NAS Enhancement

Approach:

A computationally efficient algorithm for predicting the total energy consumption of aircraft operations on the ground and in flight will be developed. This algorithm will predict the energy consumption in a flight for any given aircraft flight performance, load characteristics, and operating conditions. It will compute optimum fuel-efficient flight trajectories that will meet specific route, altitude, and time constraints imposed by the ATC system. These trajectories will be capable of being redefined dynamically as required by changing winds, weather, and ATC constraints. In particular, real-time winds and temperature data from the profilers will be used to compute fuel-efficient profile descents. Algorithms will be developed to be incorporated in onboard flight management systems for real-time fuel-efficient trajectory computations; these algorithms will also be available to the airlines for fuel-efficient flight planning and to the FAA for reducing the fuel consumption of its own aircraft. Compatible software will be developed for ATC so that appropriate elements of the ATC automation system may generate fuel-efficient ATC advisories, and be capable of providing fuel-efficient route and altitude or speed advisories to aircraft without onboard avionics. This capability will be applied to oceanic ATC to generate and control a fuel-efficient track system that can respond dynamically to wind, weather, and traffic load conditions; it will also be applied to rotorcraft operations in low-altitude, offshore, and remote areas to produce fuel-efficient routes and airspace designs for rotorcraft operations.

In addition, a model will be developed for simulating airport and airspace delay reduction, capacity improvement, and fuel efficiency. This model, SIMMOD, will be used to analyze and evaluate complex airport and airspace traffic conditions and procedures. Based on this analysis, modified airport and airspace procedures will be developed that will improve the fuel-efficiency of aircraft operations, without having an adverse impact on airport capacity and delays.

Products

- Algorithms for minimum fuel path generation for an arbitrary set of position, altitude, velocity, and time constraints
- Algorithms for the generation of a dynamic oceanic track system
- Functional specifications and operational guidelines for fuel-efficient rotorcraft operations
- Algorithms for generating profile descent trajectories using profiler data
- Algorithms and operational guidelines for minimum fuel computations within the oceanic ATC system
- SIMMOD model

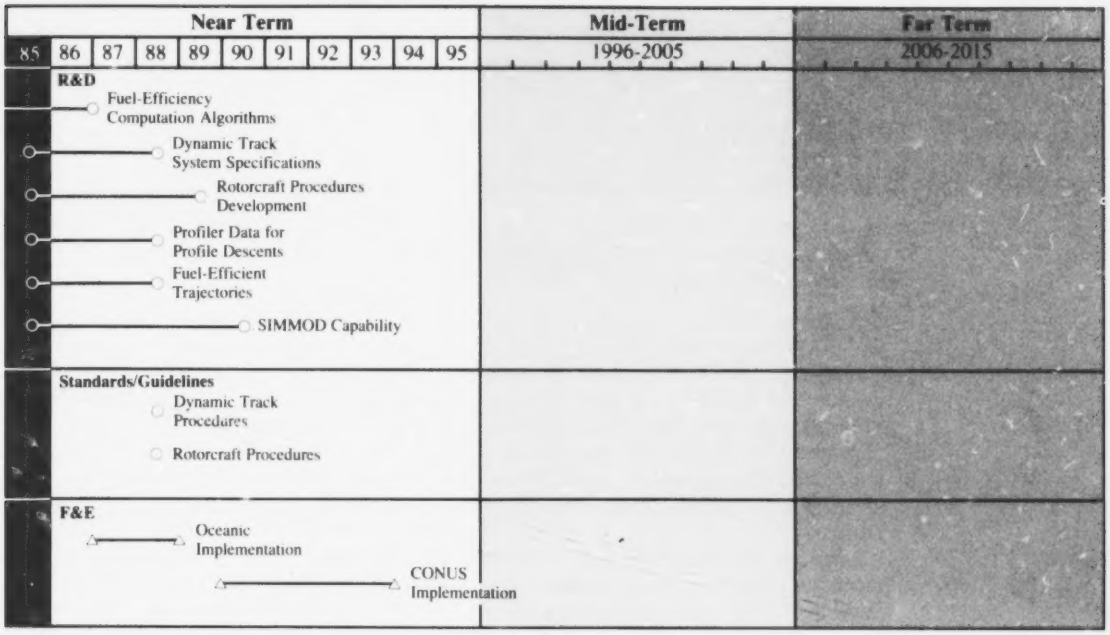
Recent Accomplishments

- Flight evaluation of the minimum fuel track and trajectory generation completed.
- Preliminary demonstration of SIMMOD accomplished by modeling aircraft traffic in the San Francisco area.
- NOPAC Track Analysis and Enhancement Plan prepared.

Related Projects/Activities

None

Schedule



3.23
Fuel Shortage Contingency Planning

Purpose

To assess the impact of a disruption in oil supply on air transportation and develop appropriate policy options for the FAA's response to such an emergency.

Category

C - NAS Enhancement

Approach

In response to Section 271(a) of the Energy Emergency Preparedness Act of 1982, the FAA is developing an Aviation Energy Emergency Contingency Plan to deal with possible fuel shortages in aviation. In support of this plan, two specific activities will be pursued under this project:

- Development of the National Oil Shortage Analysis Model (NOSAM)—A data base on national fuel supply and consumption will be created as a first step in the NOSAM development. For any given level of fuel shortage, the NOSAM model will quantify the effects in terms of 10 national economic indicators and 10 aviation indicators. The model will then evaluate any user-defined corrective policy actions by recomputing these 20 indicators. The policy options that may be evaluated with the NOSAM will include, among others, various allocation schemes, such as regulating private stocks, and allocating new supplies among industries and transportation modes; drawdown on the Strategic Petroleum Reserve (SPR); emergency ATC procedures; slot allocation; the optimization of flight planning; and encouragement to carriers to schedule only essential flights.
- Analysis of regulatory and policy options—The objectives of this effort are to develop new policies and procedures that would help maintain essential air service during an aviation fuel shortage, and to identify and evaluate ATC or other FAA procedures that can result in a rapid reduction in aviation fuel consumption while maintaining the maximum possible level of air service. To this end, a key contacts file will be developed, liaisons will be established with industry and other government personnel, and a list of possible policy options will be developed. These options will then be evaluated with the help of the NOSAM model for their effectiveness in dealing with fuel shortages.

Products

- An operational aviation fuel shortage contingency model
- Computerized data base of key industry contacts for refineries, suppliers and jobbers, pipelines, air carriers, and fixed-base operators
- Computerized data base of historical and most recent data available on fuel consumed, cost and availability, and air carrier and general aviation activity indicators
- National oil shortage analysis model report
- Policy recommendations to the Administrator for fuel crisis responses
- Description of a recommended system for continued monitoring of fuel supply spot shortages

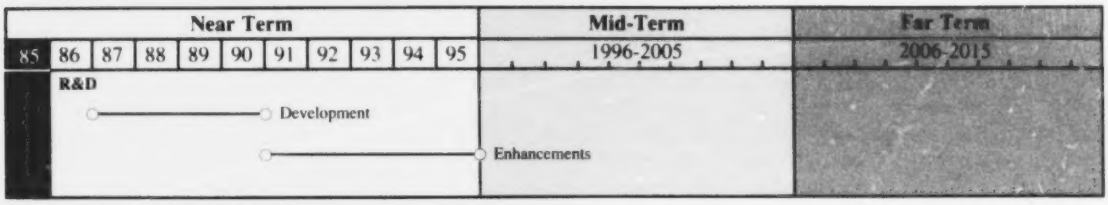
Recent Accomplishments

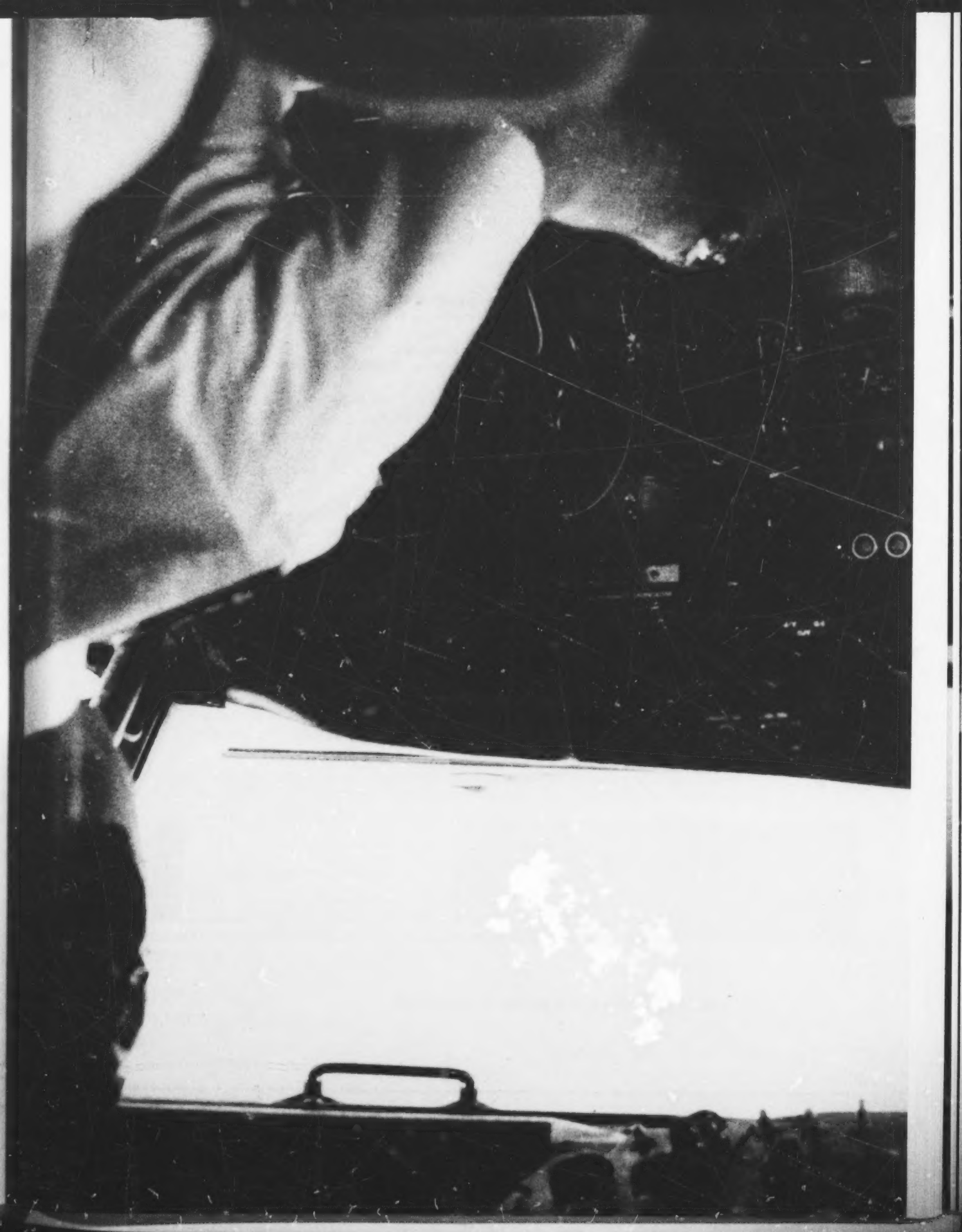
- Report on fuel price and availability in FAA Regions prepared.
- Report on differences in the manufacturing costs of automobile and general aviation fuel prepared.
- Preliminary data base on fuel price and availability developed.
- Preliminary report on the national oil shortage analysis model prepared.

Related Projects/Activities

None

Schedule





Chapter 4
Communications

Communications projects will add digital capabilities to ground-ground and air-ground communications.

The FAA community of communications users includes pilots, controllers, computer systems, surveillance equipment, weather sensors, ground-air equipment, the Department of Defense (DOD), and many others. These users are linked together today with probably the largest civil communications system in the Federal government. This system has evolved over a number of years and, like many large systems within both the government and the private sector, is really multiple networks dedicated to separate ATC functions. Most of the existing system is leased, primarily from AT&T and the Bell operating companies. It serves both civilian and military users, and is obviously critical to air safety.

The NAS Plan describes the modernization of the ATC communications network that serves ATC operators and users. A review of the plan reveals the ever-increasing dependence of the ATC system on communications. Typical examples include the planned consolidation of the over 200 existing center and terminal radar control facilities into 23 Area Control Facilities (ACFs) and the over 300 Flight Service Stations (FSSs) into 61 Automated Flight Service Stations (AFSSs), the Remote Maintenance Monitoring System (RMMS); and the implementation of an air-ground data link capability using Mode S.

This new communications system will connect 23 ACFs, over 400 towered airports, 61 AFSSs, and 60 general maintenance sectors. In addition, the system will process data from approximately 300 surveillance radars, 150 weather radars, 2,000 navigation aids, 1,200 automated weather observing systems, 1,200 remote communications facilities, and 200 data link facilities. Several national-level systems will also be connected to regional and local facilities.

Need for R,E&D

While many aspects of the FAA system are similar to those of other communications systems, there are also a number of unique characteristics, directly traceable to the very nature of ATC:

- It is a real-time system.
- Pilots and controllers are both in the loop.
- The system is subject to random perturbations, such as meteorological phenomena.
- The system is geographically dispersed.

These characteristics lead to tight coupling of adjacent airspace, both within a facility and between facilities. On the other hand, communications traffic between nonadjacent facilities, while still required, is not heavy. To provide the required communications, surveillance, and meteorological coverage, ground-air outlets, surveillance systems, and weather sensors are located in remote areas. Ground-air communications requirements are major contributors to overall ATC communications requirements.

- The general requirements for ATC communications translate to unique requirements such as the following:
- High availability in remote locations and low altitudes
- Simultaneous ground-air and ground-ground communications
- Rapid controller-to-controller call set-up
- Reconfiguration of position equipment
- Low end-to-end message delay
- Rapid fault detection, isolation, and restoration

These requirements have led to a telecommunications architecture with four major elements:

- Integrated Voice and Data Transmission System
- Voice Switching Systems
- Data Switching Systems
- Network Management and Control System

Telecommunications Projects

The basic elements of this telecommunications architecture are being implemented through a set of near-term projects described in the NAS Plan. There are, however, unique requirements that necessitate research and development efforts for selected elements of the architecture. A summary of the ground-ground telecommunications NAS Plan projects and related R,E&D projects is presented below. It should be noted that the Future Telecommunication Requirements and Architecture project will plan the evolution to an all-digital ground-ground communications system, including transmission, switching, and control elements.

Architecture Element	NAS Plan Projects	R,E&D Project
Transmission System (Radio Communications Links [RCLs])	Radar Microwave Link (RML) Trunking, Data Multiplexing, RML Replacement and Expansion, Television Microwave Link, Airport Telecommunications	Future Telecommunication Requirements and Architecture
Voice Switching Systems	Voice Switching and Control System (VSCS), Integrated Communication Switching System (ICSS), Radio Control Equipment (RCE)	VSCS
Data Switching Systems	National Airspace Data Interchange Network (NADIN) II	NADIN II
Network Management and Control System	RML Replacement and Expansion	Network Management and Control System

In addition, the FAA must maintain a posture that allows cost-effective communications technology to be integrated, at appropriate times, into the ATC system. To do this requires a continuing level of R,E&D funding for selected projects.

Air-Ground Communications

The ability of ground and airborne systems to exchange data while not imposing added workload on pilots, controllers, or specialists will be a key element of a future ATC environment that will operate more efficiently, with higher productivity, and with enhanced safety. The procurement of the Mode S system, with its integral, highly reliable data communications capability, is a necessary step toward providing this capability. However, the link itself is only an element of what must become an expansive communications architecture. Standards and guidelines for data-processing avionics must be developed that allow for the sharing of cockpit input/output devices among the independent RF links that will exist (Mode S, HF, VHF, and/or satellite). An architecture is needed that will allow for evolutionary changes to air-ground data communications, and provide the capability to extend ATC and flight services to be extended as air-ground data link availability increases.

At the same time, an expandable and flexible architecture must be developed in the NAS ground system elements to allow for the evolution of new air-ground data communications applications, and the addition of new origins and destinations of information. Mission-oriented data communications with aircraft throughout all flight phases (airport surface to at least 70,000 feet) could provide nonrepetitive, essential information on both a request-reply and automated basis, thus making full use of automation while reducing workload.

Flight and computer session services will be developed. Pilots operating under both VFR and IFR could be offered selected weather and route update information automatically. Automation elements in the ground system will use knowledge of (1) flight plan intent, (2) flight location, (3) environmental data, (4) data previously provided, and (5) the extent of data desired by the pilot to determine what information should be sent and when. Data link messages will be addressed system-wide to aircraft in real time through use of the ground system's knowledge of the location of the aircraft associated with the specific Mode S address. Automation will reduce workload by keeping track of what has been provided and anticipating the pilot's need for further information.

Mode S data link applications will be developed through the above- described architecture by integration of the data elements provided or required by the many NAS plan projects. This will result in system information products that will be transmitted by data link when appropriate. The development, test, and evaluation of a wide variety of projected air-ground data communications applications will be supported in both technical and operational contexts by the Mode S data link engineering testbed.

Communications Project Summary

Area	Project No.	Project Name
Ground-ground	4.1	Future Telecommunication Requirements and Architecture
Ground-ground	4.2	Network Management and Control System
Ground-ground, Air-ground	4.3	Voice Switching and Control System
Ground-ground	4.4	National Airspace Data Interchange Network II
Ground-ground	4.5	Telecommunications on Airport Surface
Air-ground	4.6	Rotorcraft Communications
Air-ground	4.7	Mode S Data Link Technical Enhancements
Air-ground	4.8	Mode S Data Link Applications Development

4.1
Future Telecommunication Requirements and Architecture

Purpose

To develop a plan for evolving from the present NAS Interfacility Communications System (NICS) hybrid architecture to an all-digital architecture for ground-ground communications.

Category

C—NAS Enhancement

Approach

The FAA is implementing a mixture of analog and digital communications systems, including RCE, the RCL, and VSCS. Digital communications technology is projected to decrease in cost for installation and operation. This project will determine the feasibility, cost, and impact of developing a fiber-optic system, a digital microwave system, digital RCE, and a low-density digital drop and insert capability. A digital switching architecture will be developed, and the feasibility of using packetized voice within the ACF will be determined. An intrafacility architecture will also be developed. Satellite applications to interfacility communications will be investigated in Chapter 8 of this plan.

Products

- All-digital network interfacility architecture
- Integrated voice/data intrafacility communications architecture
- Digital communications protocol standard for aviation

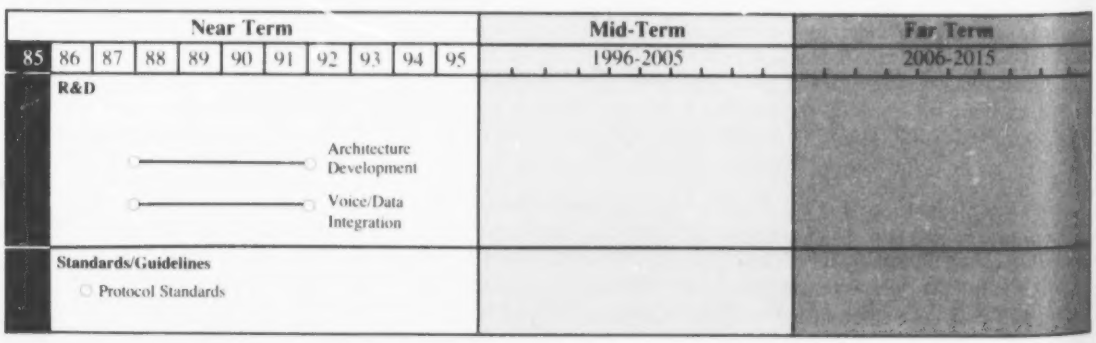
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Radio Control Equipment (NAS Plan)—will modernize existing radio tone control equipment for control and remote maintenance monitoring of facilities.
- Radar Microwave Link Replacement and Expansion (NAS Plan)—will provide a network of microwave radio communications links for voice, data, and broadband radar transmissions.
- Voice Switching and Control System—will integrate interfacility voice and data transmissions.

Schedule



4.2
Network Management and Control System

Purpose

To define telecommunications management and operations functions, and develop supporting procedures and mechanisms, including national, regional, and field support levels of control.

Category

C—NAS Enhancement

Approach

The FAA has embarked on a significant effort aimed at modernizing the ATC communications system, both the transmission and switching subsystems. The system is evolving to a primarily owned versus leased system. Telecommunications management and operations functions and capabilities must be modified/enhanced to accommodate these changes. This project will define, develop, and utilize tools to support related activities, including resource allocation, network management and control, system level performance, and real-time operation.

Products

- Definition of telecommunications management and operations function
- Network Management and Control System architecture
- Network Management and Control System specification
- Prototype Network Management and Control System
- Network tools and analyses

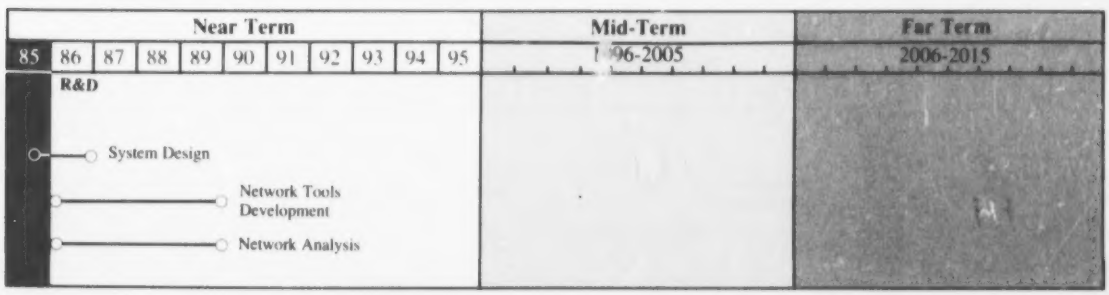
Recent Accomplishments

None

Related Projects/Activities

- Radar Microwave Link Replacement and Expansion (NAS Plan)—will provide a network of microwave radio communications links for voice, data, and broadband radar transmissions.
- National Airspace Data Interchange Network II—will provide expanded data switching capability and network monitoring functions.
- Voice Switching and Control System—will integrate interfacility voice and data transmissions.

Schedule



4.3
Voice Switching and Control System

Purpose

To develop a Voice Switching and Control System (VSCS) that will perform the intercom, interphone, and air-ground voice connectivity and control functions needed for ATC operations in an ACF. The VSCS must satisfy the voice communications reconfiguration and service availability needs of the ACFs, reduce leased service costs, increase modularity and growth capability, and increase controller productivity.

Category

B—Direct Support of NAS Plan

Approach

The VSCS will use existing off-the-shelf technology, adapted to meet FAA requirements. Two competing designs will be evaluated prior to the development of final specifications and award of the production contract. In addition to the R,E&D activities described in the NAS Plan, prototype development and testing and evaluation of VSCS will be conducted.

In order to ensure compatibility of the AAS and VSCS man/machine interface, the VSCS contractors will produce VSCS Sector Suite position equipment according to specifications provided by the AAS contractors. An interface with the AAS is required for reconfiguration and status reporting purposes. A set of predetermined reconfiguration maps will be embedded in the VSCS. The capability to modify or create new reconfiguration maps from designated VSCS positions will be provided.

Products

- Two VSCS prototype systems
- Test and evaluation report
- Specifications for production contract award

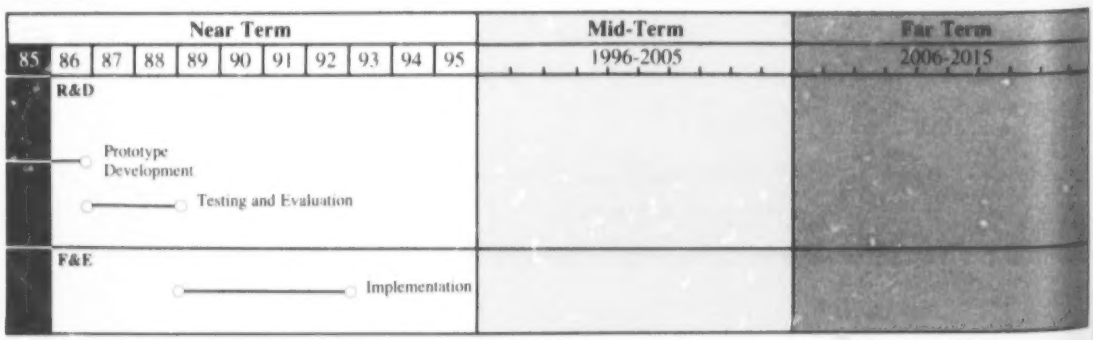
Recent Accomplishments

None

Related Projects/Activities

- Radio Control Equipment (NAS Plan), Integrated Communication Switching System (NAS Plan), and Tower Communications System (NAS Plan)—these projects will provide interface specifications.
- Advanced Automation System—VSCS must be available and installed concurrently with the Initial Sector Suite System provided by the AAS project.

Schedule



4.4
National Airspace Data Interchange Network II

Purpose

To analyze, design, and specify enhancements to the National Airspace Data Interchange Network (NADIN) that will meet the data transfer requirements of the major FAA project functions and facilities in the NAS Plan. NADIN, as it evolves, will provide a cost-effective integrated, common user data transfer system. The resultant communications system will substantially reduce the number of dedicated circuits and their associated cost.

Category

B—Direct Support of NAS Plan

Approach

NADIN II system design is based on the data transmission requirements of new systems and the consolidation of present systems. This communications utility will be coordinated with other FAA communications initiatives to provide the required trunking and transmission facilities. NADIN II development involves a two-phase approach, to result in a single specification that will satisfy both Phase 1 and Phase 2 requirements. Phase 1 will provide packet switching nodes with virtual circuit and alternate routing capability, centralized network control and monitoring, and added trunking. Phase 2 will provide the capability for system enhancements, including additional system capacity, connectivity, and interfaces. The standardization of access interfaces and exchange protocols will be specified to ensure future flexibility for system evolution. Message switching will continue to be provided, as will quick response interactive data transfer, efficient file transfer, and database transfer capabilities.

Evolution of the ATC system to provide the capability for a standard interface to NADIN II will require the development of new network management capabilities. A protocol conversion capability will allow the existing FAA terminal equipments to interoperate with the standard NADIN II interface. In addition, the capability to interface NADIN II to the existing message switching systems will require the development of a gateway capability between networks.

Products

- NADIN II enhancements design
- Protocol conversion specification
- Gateway specification

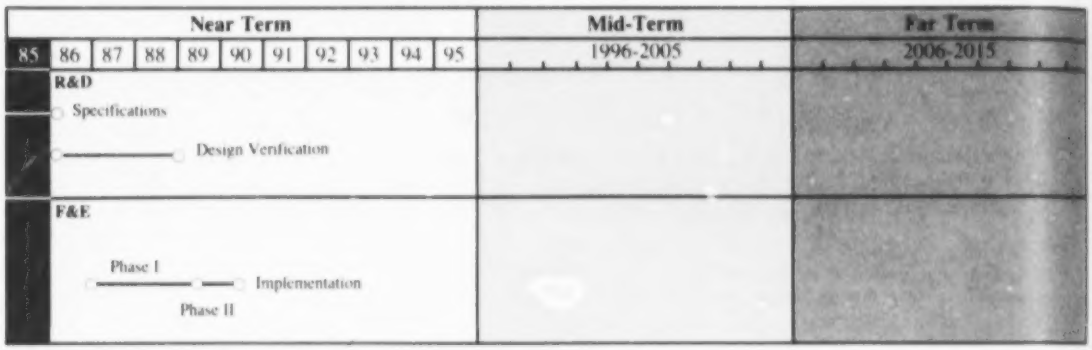
Recent Accomplishments

None

Related Projects/Activities

- National Airspace Data Interchange Network (NAS Plan)—provides interface with NAS operational systems requiring interfacility data transfer.
- Area Control Facilities (NAS Plan)—future needs for the ACFs and AAS will be met by these NADIN enhancements.
- Remote Maintenance Monitoring System (NAS Plan)—NADIN will also satisfy Maintenance Management System data transmission requirements.

Schedule



4.5
Telecommunications on Airport Surface

Purpose

To study cost-effective and efficient alternatives for collecting and distributing data among various sources and destinations in the terminal facility environment, given that the installation and maintenance of underground cables are expensive and disruptive to normal airport operations.

Category

C—NAS Enhancement

Approach

Packet radio (RF) data links may be a feasible alternative to the use of underground cables for transmitting data, signal, and control information at airports. The technical and operational feasibility of another alternative—fiber optics—for voice, control, signal, and data transmissions at airports will be determined. Fiber optics are resistant to lightning-induced surges and electromagnetic noise from power cables. In general, they are smaller than equivalent metallic conductor cable, and they can be installed concurrently with power cables to provide additional cost reduction. Practical aspects will be investigated, such as installation constraints, splicing techniques, interfacing, and environmental factors.

Problems associated with radio propagation will be studied as they apply to the packet radio technique in a terminal facility environment. Guidelines, procedures, and specifications for equipment acquisition, installation, and operation will be developed. The suitability and availability of commercially produced equipment will be assessed.

Products

- Feasibility report
- Equipment selection recommendations
- Operational guidelines
- Equipment standards

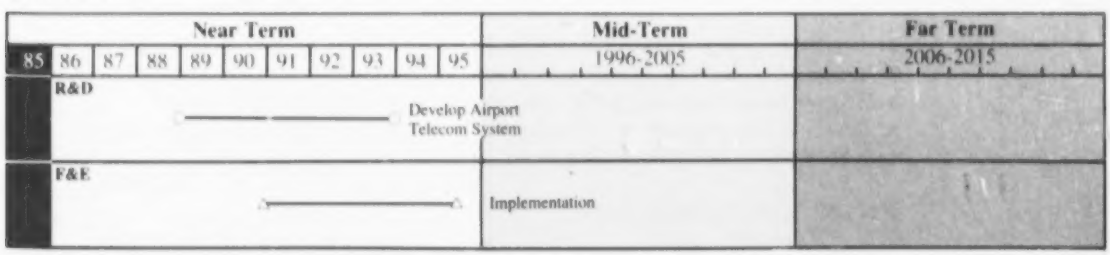
Recent Accomplishments

None

Related Projects/Activities

- Airport Power Cable Loop Systems (NAS Plan)—may provide installation of the airport telecommunications system.

Schedule



4.6
Rotorcraft Communications

Purpose

To improve low-altitude and remote area communications services provided by the NAS. There is a growing need for NAS services to support increasing IFR helicopter operations; reliable communications are essential for IFR operations and ATC services. Service coverage and reliability improvements will be sought through alternate technologies, as well as through more efficient use of today's VHF voice system.

Category

C—NAS Enhancement

Approach

Near-term benefits for rotorcraft operators can be realized through innovative use of the existing VHF/AM air-ground communications system. This R,E&D effort will consist of two basic thrusts:

- Equipment selection recommendations and installation practices—Many of today's helicopters use fixed-wing equipment and mount antennas in arbitrarily placed locations, and suffer unnecessary performance penalties as a result. Guidelines for use by equipment manufacturers, installers, and operators will be developed to maximize the performance of existing systems.
- Geographical siting of ground facilities—Past experience will be used to solve specific geographical-area problems through the use of terrain-based propagation models, directional antenna arrays, and frequency planning techniques. Methodology, analytical tools, and guidelines will be developed to improve VHF/AM low-altitude and remote area coverage.

VHF/AM is limited to line-of-sight, and the installation of extensive additions to the existing network of VHF/AM stations is not economically feasible. Alternate techniques will be developed and evaluated for possible implementation. In remote, low-density traffic areas, where bandwidth requirements are lower and there is a need for reliable communications without large numbers of distributed stations, new HF techniques will be evaluated, including adaptive HF and nearly vertical incident skywave systems. U.S. Army communications experience gained through nap-of-earth helicopter operations will be reviewed.

Various data link systems will be evaluated for basic link performance toward improving the reliability and efficiency of voice communications. The partial replacement of voice with data presented by alphanumeric displays, voice synthesizers, and guidance/situation displays will also be evaluated.

The application of satellite communications to helicopter operations will be evaluated in Chapter 8 of this plan. NAS implementation will depend upon a number of factors. Various technical improvement options will be assessed for communications performance, coverage, reliability, and cost. Under a related effort, current and projected needs for service, and benefits associated with service improvements, will be estimated. The implementation of NAS communications improvements will be a function of costs vs. benefits associated with each potential option, as well as the ease with which various improvements can be integrated into the system.

Products

- Advisory circular material for the selection and installation of aircraft VHF/AM voice equipment
- Reference manual for improving low-altitude and remote area communications service
- HF communications technology assessment, testing, and evaluation report
- Data link communications technology assessment, testing, and evaluation report
- NAS implementation analysis and decision data package

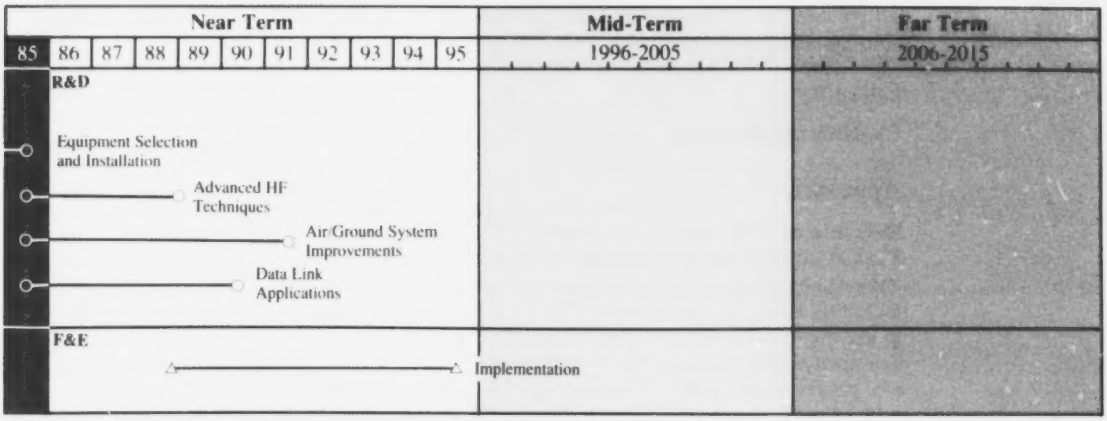
Recent Accomplishments

None

Related Projects/Activities

None

Schedule



4.7
Mode S Data Link Technical Enhancements

Purpose

To provide the technology and tools needed to implement the Mode S data link system as the air-ground data communications element within the NAS.

Category

C—NAS Enhancement

Approach

Data link avionics and cockpit input/output devices will be developed and tested in an effort to define the Mode S airborne architecture and standards, including those for pilot interaction. A Mode S data link engineering testbed will be developed, capable of demonstrating, testing, and evaluating proposed applications, including advanced automation. Project activities will include assessment of the ability of the Mode S data link to use the ground system's knowledge of (1) pilot intent as expressed by flight plans, (2) the location of Mode S equipped aircraft as detected by surveillance, and (3) sensor-gathered environmental data. The Mode S data link will be developed so that it can use this knowledge to anticipate information exchange opportunities, and initiate such exchanges automatically among VFR and IFR aircraft; this will allow aircraft in all mission phases to exchange data having any NAS origin or destination. Increased Mode S data link service to equipped VFR aircraft will reduce IFR demand for separation services. Additionally, the government will assist in the development of guidelines, standards and operational concepts needed for related avionics development, and for the interoperability of independent air-ground data communications systems (VHF, HF, satellite, and others); this may serve to ensure the wide implementation of Mode S data link.

Cost-benefit studies of proposed air-ground data communications applications will be conducted in an effort to determine the priority of Mode S services and the order of their implementation. Guidelines for service implementation will be developed. These guidelines will control data link use and ensure consistent presentation of information to the pilot. Application-independent communications protocols and message coding standards for text, graphical, and bit-oriented air-ground data link communications will also be developed. Interfaces between Mode S and all NAS Plan projects that provide or use data will be defined. Technical guidance will be provided as appropriate.

Products

- Development Systems

  Mode S data link engineering testbed and other engineering tools

  Testbed Mode S data link avionics (processors and input/output devices)

  Prototype Mode S data link airport surface coverage system

- Software

  Application-independent communications protocols and message-coding algorithms

  Interfaces between Mode S and NAS Plan projects that provide or use data

- Technical Guidance Data

  Data Link National Aviation System Standard

  Data Link Interoperability Guidelines and Standards

  Data for the Radio Technical Commission for Aeronautics (RTCA) process that is developing Minimum Operational Performance Standards (MOPS), and for the development of International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS)

- Requirements and Analyses

  Architectural and Operational Requirements for Mode S data link, needed to optimize interfaces with the AAS, Flight Service Automation System (FSAS), and Central Weather Processor (CWP)

  Correlation of graphical data link weather presentation to actual weather observed by the pilot to enable product improvement

  User/FAA cost-benefit studies of feasible data link applications to determine service priority and implementation order

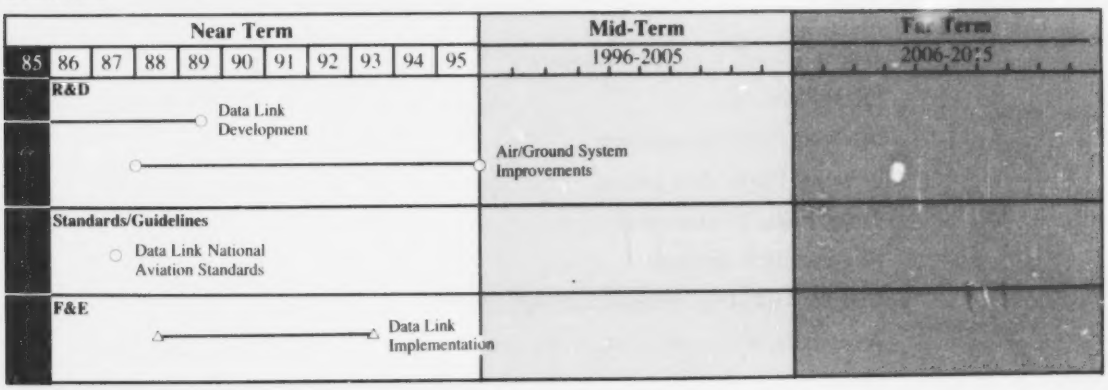
Recent Accomplishments

- Mode S Transponder MOPS published by RTCA.
- Technical Guidance for Mode S data link technical enhancements.
- Mode S Data Link National Aviation Draft Standard published.
- Mode S Transponder Proposed Technical Service Order (TSO) published by the FAA.
- Worldwide information circular on the Mode S Transponder published by ICAO; Draft International Standard for Mode S approved by ICAO.

Related Projects/Activities

- Mode S Data Link (NAS Plan)—provides the 2-way RF data link with aircraft equipped with the Mode S Transponder.
- Weather Communications Processor (NAS Plan)—provides message translation and sensor routing for all flight service applications.
- Advanced Automation System—provides all ATC data link processing and association of aircraft with Mode S sensors.
- National Airspace Data Interchange Network II—provides the communications paths between the Mode S sensors and the NAS ground system elements.
- Automated En Route ATC—provides the algorithms required to generate the air-ground data exchanges needed to implement the airspace management concept.
- Mode S Data Link Applications Development—develops the applications that will be evaluated using the Mode S data link engineering testbed.
- Various weather data bases and sensors to be developed under the NAS Plan—will be potential sources of information that could be used in data link services, and include the Flight Service Data Processing System (FSDPS), Central Weather Processor (CWP), Aviation Weather Processor (AWP), Next Generation Weather Radar (NEXRAD), and Automated Weather Observing System (AWOS).
- Airport Surface Surveillance—provides Mode S data communications with aircraft on the airport surface.

Schedule



4.8
Mode S Data Link Applications Development

Purpose

To develop Mode S data link applications needed to provide the user with improved air-ground data communications services and achieve NAS Plan goals of higher productivity, increased efficiency, and enhanced safety; this effort will support the creation of the future ATC environment.

Category

C—NAS Enhancement

Approach

Activities in this project will include developing, testing, and validating operational concepts for several Mode S data link applications, and defining message flows, content, and format for each application; message processing algorithms; and specific human interfaces. Cost-benefit studies of promising air-ground data communications applications will be conducted to determine the priority of services to be provided and the order of their implementation.

Applications to be examined include the following

- Air-ground data exchanges (some totally automated) necessary to allow real-time flight plan processing on the aircraft
- Provision of automatic traffic, terrain, and airspace advisories
- Exchange of surveillance data
- Automatic generation of sequencing and spacing clearances
- Surface traffic management aids
- Automated airport services at both manned and unmanned facilities
- Automated weather update information and hard-copy automated terminal information service (ATIS) for equipped VFR and IFR aircraft
- Automated aircraft weather-reporting systems
- Automated display of hazardous weather in the cockpit
- VFR flight following by advising both FSAS and the aircraft of the Mode S-determined position
- Weather graphic products for low-cost avionics applications

Products

- Operational concepts for each application developed
- Applications and interface software needed to implement those services found to be feasible and cost-beneficial
- Demonstration, test, and evaluation of applications

  Flight Planning

  En Route Flight Management

  Terminal Flight Management

  Tower Flight Management

  Weather Flight Services

- Data for validating concepts and applications

  Assessment of benefits, costs, risks, and system impact of promising applications

  Development of in-service transition strategies for approved concepts and accepted applications

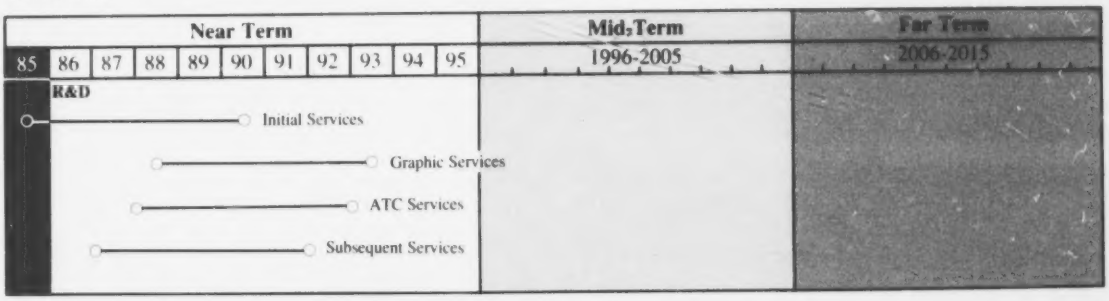
Recent Accomplishments

- Initial data link weather services proposed.
- Initial data link ATC services proposed.

Related Projects/Activities

- Mode S/Data Link (NAS Plan)—provides 2-way RF data link with aircraft equipped with Mode S transponders.
- Weather Communications Processor (NAS Plan)—provides message translation and sensor routing for all flight service applications.
- Advanced Automation System—provides ATC data link processing and interface of aircraft with Mode S sensors.
- National Airspace Data Interchange Network II—provides the communications paths between Mode S sensors and the NAS ground system elements.
- Automated En Route ATC—provides the algorithms required to generate the air-ground data exchanges needed to implement airspace management.
- Flight Service Automation System (NAS Plan)—provides textual weather products for transmission to aircraft via Mode S data link.
- Central Weather Processor (NAS Plan)—provides graphic weather products for transmisssion to aircraft via Mode S data link; AWP, NEXRAD, and AWOS will provide data for products.
- Mode S Data Link Technical Enhancements—the Mode S data link engineering testbed will be used to demonstrate, test, and evaluate data link applications.

Schedule



Chapter 5
Navigation and Landing

Navigation and landing projects will investigate the mix of systems needed to satisfy changing aviation requirements.

The FAA has the responsibility for developing and implementing radionavigation systems to meet the need for safe and efficient navigation and control of all civil and a significant portion of military aviation. The Federal Radionavigation Plan (FRP), jointly developed by the Department of Defense (DOD) and the Department of Transportation (DOT), sets forth an approach to the implementation and operation of radionavigation systems that ensures the efficient use of resources and the full protection of national interests.

There is significant activity already underway related to the modernization of navigation and landing services provided by the FAA. In accordance with the NAS Plan, vacuum tube equipment used in the VHF Omnidirectional Range (VOR), Distance Measuring Equipment (DME), Tactical Aircraft Control and Navigation (TACAN), Non-Directional Beacon (NDB), and Direction Finder (DF) systems is being replaced with solid-state equipment. Remote maintenance monitoring is being implemented to improve system reliability, maintainability, and availability while also reducing cost. The Microwave Landing System (MLS) has been adopted as the international standard approach and landing system to replace the Instrument Landing System (ILS). Long Range Navigation (Loran C) is being extended to provide continuous coverage (including low-altitude and remote areas) throughout the conterminous United States (CONUS) as a supplemental navigation service for en route and terminal Instrument Flight Rules (IFR) operations.

The R,E&D projects presented in this chapter respond to the recommended policies and plans set forth in the FRP and to the expressed needs of airspace users. However, as user needs continue to evolve and demands on the NAS continue to grow, alternative system concepts and technologies need to be examined. As an example, helicopter operators require low-altitude, high-accuracy navigation coverage in urban areas where Loran C may not be adequate. Effective integration of Area Navigation (RNAV) capability into the NAS is needed so that users can realize the full extent of fuel savings and other benefits made possible by that concept. One example of an existing inefficiency is the use of latitude/longitude by the pilot to define RNAV waypoints, while the ground controller uses bearing/distance from a VOR, or other geographical fix, for aircraft positioning. With regard to precision approach and landing services, operation-specific standards and procedures need to be developed for conventional take-off and landing (CTOL), short take-off and landing (STOL), and vertical take-off and landing (VTOL) aircraft to permit use of the wide-angle coverage capabilities and growth features (e.g., 360 degree azimuth function) of MLS. Other planned MLS support activity includes the definition of lighting system requirements, and the development of appropriate International Civil Aviation Organization (ICAO) standards and guidance material for MLS installations.

Through a joint DOD/DOT policy statement, agreement has been reached to pursue approval of the Global Positioning System (GPS) as a supplemental en route navigation system, with the eventual goal of its certification as a sole-means navigation system. The R,E&D necessary to support the integration of GPS into the NAS is addressed in Chapter 8 (Satellite Applications).

The results of these activities will be examined and used as input to the biennial FRP update. This will serve to refine the recommendations for the mix of systems needed to satisfy civil and military aviation requirements.

Navigation and Landing Project Summary

Area	Project Number	Project Name
Efficiency	5.1	Enhancements to Current Navigation Systems
Position	5.2	Area Navigation
Procedures	5.3	Precision Approach and Landing
Position	5.4	Future Navigation Systems

5.1
Enhancements to Current Navigation Systems

Purpose

To expand the utility, improve the performance, and increase the efficiency of the use of navigation systems currently operated and maintained by the FAA.

Category

C—NAS Enhancement

Approach

As stated in the FRP, the FAA will continue its ongoing modernization and sustaining engineering of existing ground-based navigation aids in an effort to reduce Operations and Maintenance (O&M) costs and improve performance. Available technology will be identified and assessed for its application to navigation aids that would improve performance or meet new requirements. An example would be improving the VOR antenna system to reduce sensitivity to the site environment. An assessment will be made of the technical feasibility and potential benefit of adding functions within the VOR, DME, or NDB radiofrequency spectrums with no degradation in existing service (e.g., the use of spread spectrum techniques to transmit navigation data to aircraft).

Alternative concepts will be investigated for improving navigation service in oceanic and remote areas (e.g., Alaska) where present service is either poor or nonexistent. In this connection, consideration will be given to the special helicopter navigation requirements attributable to operations at low altitudes and in remote areas.

Candidate enhancement concepts will be evaluated through the simulation of operational applications. When necessary to validate the achievable performance of recommended concepts, prototype hardware and software will be developed for limited operational evaluations (e.g., the application of one-way ranging techniques to DME).

Based on the results of the tests and evaluations, operational guidelines and equipment design specifications will be developed. The use of alternative systems for nonprecision approach operations will require the development of system-specific operational procedures. For example, the use of differential Loran C will require definition of the form and means of providing differential corrections to the aircraft.

Products

- Reports on the technical, operational, and economic assessment of adding new functions to existing navigation aids
- Evaluation of prototype navigation system improvements
- Specifications for improvements to ground-based systems
- Revised standards for performance and design of systems

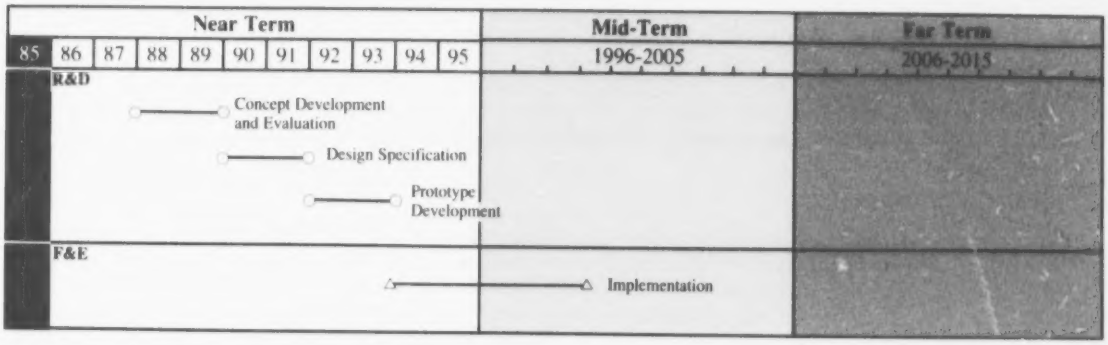
Recent Accomplishments

None

Related Projects/Activities

- Future Navigation Systems—enhancements to navigational systems will be incorporated into the FRP.

Schedule



5.2
Area Navigation

Purpose

To develop avionics performance standards that will permit direct routing of aircraft equipped with Area Navigation (RNAV) systems.

Category

C—NAS Enhancement

Approach

An assessment will be made of the degree of performance variance between the variety of RNAV avionics in use. Based on established requirements and the results of this assessment, avionics performance standards and approval guidelines will be developed to ensure the ability of different RNAV systems to operate concurrently in common airspace with safety. Alternative navigation coordinate reference concepts will be evaluated to permit fuller exploitation of RNAV capabilities through the adoption of a common reference for both the airborne RNAV equipment and the ATC system. A desired application of the coordinate reference concept would be to permit a more effective means of defining and referencing waypoints, thus eliminating the problems of pilot workload, pilot error, and system integration currently associated with the use of waypoints designated by latitude/longitude. Methods for managing airborne navigation data bases will be investigated, with the goal of ensuring that aircraft and ATC are using common reference information.

Products

- A report presenting a detailed comparative evaluation of the technical and operational performance characteristics of different RNAV systems
- A report presenting a comparative assessment, including operational impacts, of alternative navigation coordinate grids
- A report on airborne database management methods

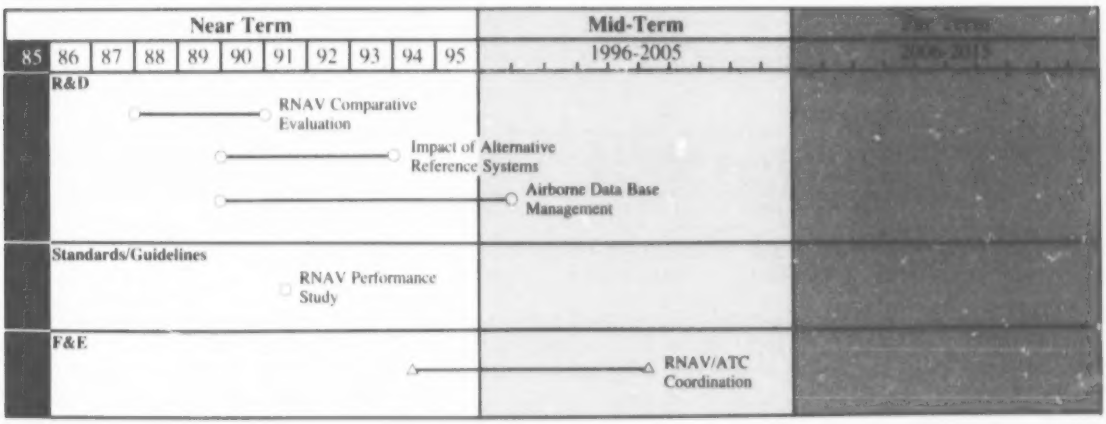
Recent Accomplishments

None

Related Projects/Activities

- 4D Navigation in ATC—investigation of an alternative navigation coordinate reference concept requires mutual consideration for development and implementation.
- Avionics Certification R,E&D—criteria for certification of RNAV avionics are needed to permit the application of full RNAV capabilities.

Schedule



5.3
Precision Approach and Landing

Purpose

To complete the development of operational procedures and criteria for advanced MLS configurations and special applications.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

MLS has been adopted by the ICAO as the international standard approach and landing system to replace ILS. The azimuth and elevation stations, plus the associated Precision Distance Measuring Equipment (DME/P), will support a variety of curved and segmented RNAV approach paths.

Research and development for MLS will continue in three general areas to both support and enhance the NAS Plan activities:

- The development of operational procedures, criteria, and avionics specifications for use of the wide-angle coverage capability of MLS—Operational procedures will be developed for the use of selectable azimuth and elevation, segmented paths, and curved paths. These procedures will be coordinated with efforts to provide airport capacity improvement through the use of multiple instrument approaches. Criteria will be developed for minimum straight segments, cockpit procedures for use of MLS auxiliary data, and decelerated approaches. Criteria and standards will be incorporated into updates of the Terminal Instrument Procedures (TERPS) document, with consideration given to the unique capabilities of rotorcraft. Support will be provided to the development of MLS RNAV avionics.
- Continued development of ICAO standards—Work will continue on developing standards for implementing MLS on a worldwide basis. Guidance material on the use of MLS auxiliary data will be developed, as will standards for Category (CAT) II/III operations and DME/P Standard 2.
- The development of specifications for MLS enhancements and special applications—Prototype hardware and software specifications will be developed for MLS enhancements and special applications, such as split-azimuth siting and 360° coverage. Word format standards for the use of auxiliary data link will also be developed.

Additional research will be performed to develop requirements for runway approach lighting for variable MLS approaches. Implementation plans for MLS at some locations do not include Medium-Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) because of possible obstructions to the plane of the MALSR, or excessive costs for installation given the terrain.

Products

- ICAO standards and guidance material for MLS auxiliary data, CAT II/III, split azimuth, 360° azimuth, DME/P Standard 2, ILS/MLS collocation, offset azimuth, and secondary runways
- Operational procedures and criteria for advisory circulars, and ground and flight inspections
- Specifications for prototype equipment and procurement packages for MLS enhancements, such as split azimuth, 360° coverage, DME/P Standard 2, auxiliary data, and offset azimuth
- Requirements for runway approach lighting with variable MLS approaches

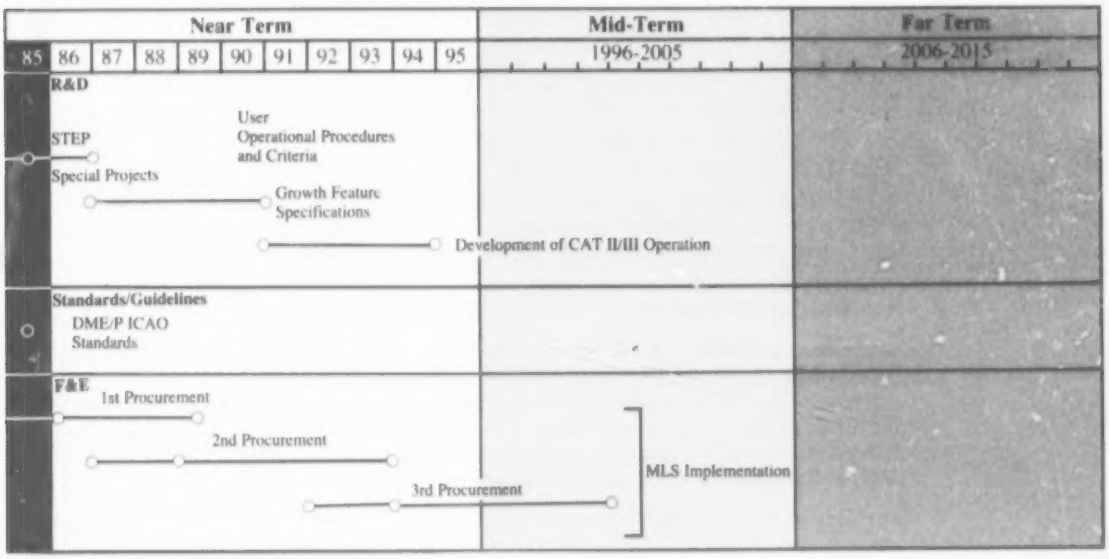
Recent Accomplishments

None

Related Projects/Activities

- Medium-Intensity Approach Lighting System with Runway Alignment Indicator Lights (NAS Plan)—not electrically linked, but MLS at most locations will include MALSR as part of the total operational system.
- Runway Visual Range (NAS Plan)—all MLS installations requiring CAT II approaches will require RVR systems.
- Airport Capacity Improvements—several concepts currently under development for using multiple instrument approaches would benefit from the MLS's capability to provide curved, segmented, and variable glide slope approaches. Such procedures are necessary to support the full capabilities of MLS.
- Microwave Landing System (NAS Plan)—the results of the operational Service Test and Evaluation Program (STEP) under this project will be used to develop operational procedures for MLS.

Schedule



5.4
Future Navigation Systems

Purpose

To identify and evaluate emerging technologies and new concepts for application in the necessary evolution of navigation services to satisfy future requirements. This project will support the biennial revision of the FRP, providing the FAA input to the joint DOT/DOD Navigation Working Group. In recognition of the finite service life of systems, future navigation system candidates will be developed as extensions of, or alternatives to, existing or planned navigation systems to satisfy projected user requirements through the year 2015.

Category

E—New Initiatives

Approach

Future navigation system candidates must be subjected to a total system analysis addressing safety and economic performance, as well as an operational and technical assessment. At a minimum, decisions regarding selection of the future system should satisfy the following criteria:

- Provide the necessary service to meet the needs of the civil aviation community.
- Be flexible and responsive to changing operational and technological environments.
- Accommodate a necessary degree of standardization and interoperability for both domestic and foreign operations.
- Achieve the required level of service in a cost-effective manner.

Algorithms and candidate systems will be developed and applied in laboratory simulations to demonstrate the feasibility and effectiveness of proposed concepts (e.g., geostationary satellite system, one-way ranging systems). The relative merits and deficiencies of candidate systems will be identified and assessed in comparison with requirements. Based on results of the tests and evaluations, including the development and limited operational evaluations of prototypes when appropriate, technical and functional design specifications will be developed for the recommended system.

In addition, supplemental studies and analyses will be performed as necessary in an effort to formulate and support more fully the FAA input to the Navigation Working Group; this input relates to the refinement of recommendations published in the FRP on the mix of systems needed to satisfy civil aviation requirements.

Products

- A report presenting a comparative assessment (technical, operational, economic) of candidate navigation system concepts
- Biennial publication of the FRP.
- A report describing the results of operational evaluations of recommended system concepts on the basis of laboratory simulations and the limited deployment of prototype systems
- Specifications for the desired technical and operational design characteristics of the recommended system
- A report presenting guidelines for transition to the recommended system

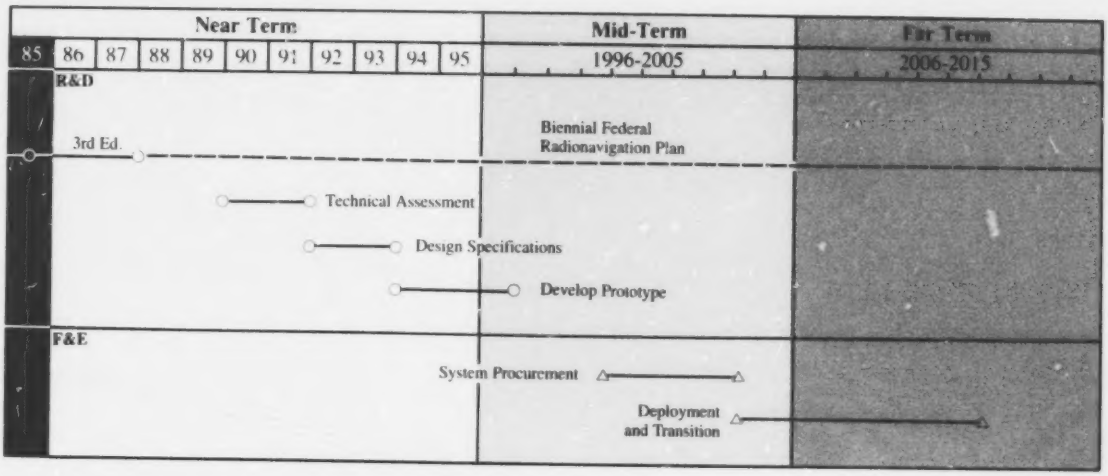
Recent Accomplishments

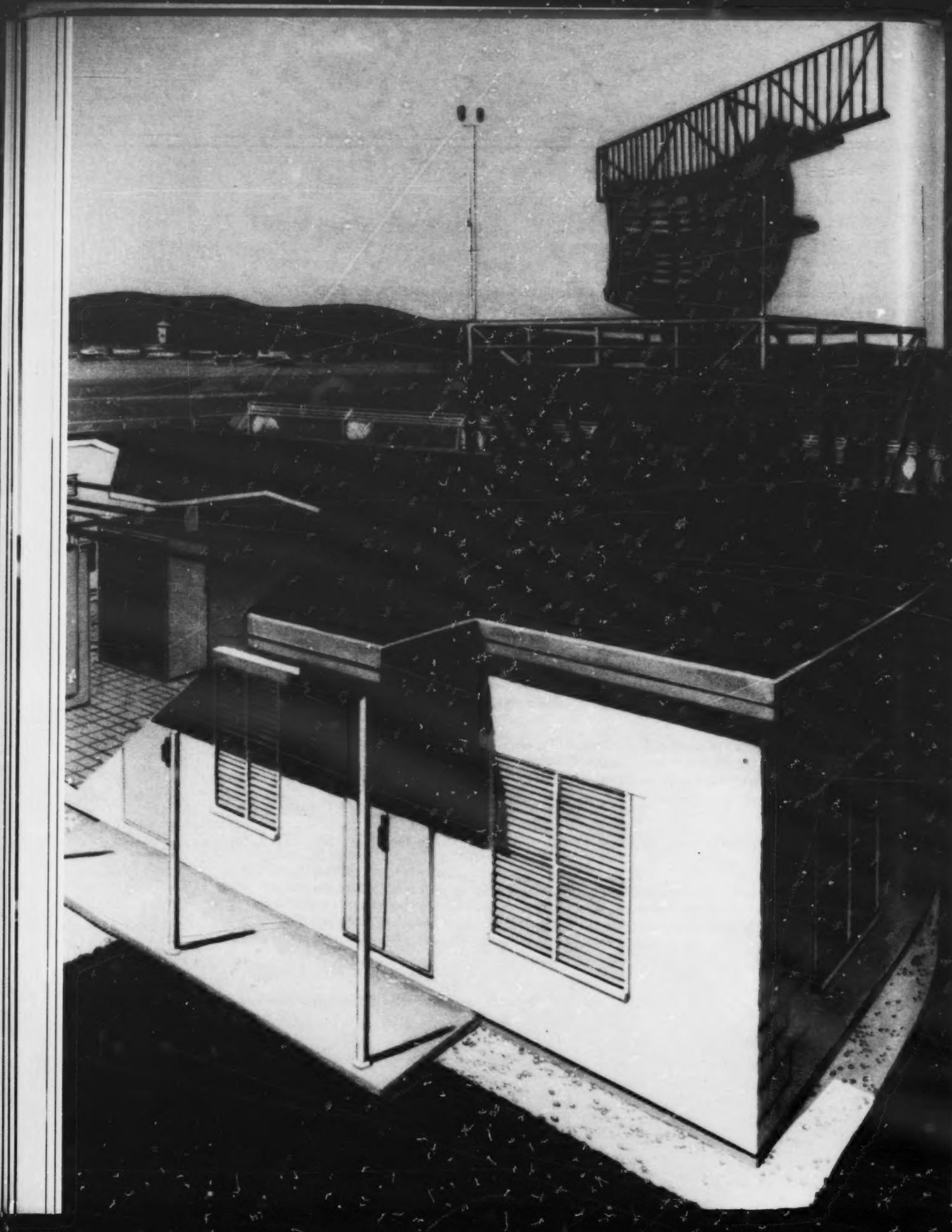
- Third edition of the FRP published.

Related Projects/Activities

None

Schedule





Chapter 6
Surveillance

Surveillance projects will provide updates to current systems and investigate new surveillance techniques.

Surveillance supports the radar separation standards used throughout the NAS. This function is currently provided by secondary and primary radars: the secondary radar uses a transponder aboard the aircraft to transmit a response to an interrogation signal so that the ground site can measure range and azimuth angle; the primary radar makes these measurements without reliance on the aircraft transponder. The aircraft must also transmit its altitude. Weaknesses in the current surveillance system include altimeter errors, mutual interference resulting in garbled replies for the secondary radar, and interference from birds, insects, and ground vehicles for the primary system. The NAS Plan will provide a new secondary radar—Mode S—and three new primary radars—Airport Surveillance Radar (ASR)-9, and 2D and 3D long-range radars. These radars will use digital technology to provide a surveillance capability with increased accuracy and reliability.

Surveillance R,E&D activities are concerned with supporting and improving the capabilities of ongoing projects by updating current surveillance systems and, where feasible and cost-effective, transitioning to new surveillance techniques. The major R,E&D areas are as follows:

- Ground-based independent surveillance—enhancements to current sensors that will provide a uniform level of performance, and the investigation/implementation of advanced sensor technology and special-purpose sensors for enhancing coverage in low-altitude areas.
- Surface surveillance—providing effective surveillance of vehicles on the airport surface.
- Dependent surveillance—developing a method of aircraft surveillance in which information related to aircraft position is generated on board and transmitted to the ground-based ATC system without the use of independent (primary radar) sensors.

Ground-Based Independent Surveillance

The Mode S, ASR-9, and 2D and 3D long-range radars are expected to serve as the backbone of the FAA surveillance system through the year 2015. Surveillance of transponder-equipped aircraft will be provided by Mode S sensors, nearly 200 of which will be in service by the end of the near-term period. Improvement in primary radar coverage for terminal areas will be provided by the ASR-9, which incorporates modern moving target detector technology. ASR-9 radars will be operational at all Terminal Control Areas (TCAs) by the end of the near term. En route coverage will be enhanced through the acquisition of 3D radars for use at joint-use sites. This implementation will free FAA radars currently at these sites for use in upgrading the equipment at other en route sites. The new 2D radar will be added to the surveillance network in the mid-term. Through these acquisitions, the FAA will have surveillance sensors in place capable of providing primary and secondary coverage down to 6000 feet mean sea level (MSL) or Minimum En Route Altitude (MEA) throughout CONUS where required.

The implementation of these improved surveillance *sensors* does not mean that development of the surveillance *system* has been completed. Additional development is needed to improve the quality of the merging of sensor data (1) at the sensor site for the integration of primary and secondary surveillance data, and (2) at the ATC facility to improve the quality of multiple sensor data processing beyond what could be provided by a single sensor site. The realization of these improvements will result in higher quality, more reliable, and more standardized surveillance data that will reduce the processing requirements of functions using surveillance data, as well as improve the overall operation of the system.

Until the new radars are installed, improvements can be made to existing radars using processing techniques such as the moving target detectors developed for the ASR-9.

In addition, where feasible, other types of radar technologies will be investigated for development, including electronic scan systems and over-the-horizon radars. Several special applications will also be included in the R,E&D efforts, including a Terminal Doppler Weather Radar for wind shear and clear-air turbulence detection, and a surveillance system for landings on closely spaced parallel runways.

Surface Surveillance

The goal of this activity is to provide a capability to detect, locate precisely, and identify all aircraft on the maneuvering area of an airport, and to monitor the movement of ground vehicles operating in the area.

The need for improved safety on the airport surface is already apparent and will become more so as MLS is deployed, allowing operations under more limited visibility conditions.

Currently, ground traffic monitoring and management involve a labor-intensive process that utilizes visual and radar surveillance and voice communications. Current equipment deficiencies and the communications procedures required to establish aircraft identity limit the number of operations possible during periods of low visibility. The primary deficiency of the present system is the lack of automated identification of aircraft under surveillance. The surface surveillance research project will develop a technique for providing vehicle identification on the surface surveillance radar.

Dependent Surveillance

Dependent surveillance is a technique that uses aircraft-derived position data. It is implemented today when a pilot reports his position by voice, based on either cockpit displays of onboard instrumentation or visual fixes. The automatic reporting of Mode C altitude depends on the onboard altimeter. The goal of this R,E&D effort will be to derive horizontal position from aircraft avionics with sufficient accuracy and timeliness such that the data can be used for positive aircraft control.

This type of information transfer is needed in the special situation of oceanic ATC. In this area, surveillance coverage is unavailable, but navigation services are available. Communication services can be provided at lower cost than surveillance coverage; therefore, by transmitting the navigation position derived in the aircraft to ATC, a surveillance function can be provided.

Today, position reporting from the aircraft is prone to large inaccuracies due to human error, erroneous conditions occurring in the avionics not known to the pilot, and the reporting of data that represent a past aircraft position (sometimes 10 to 20 minutes past the time the aircraft arrives at a controller's position). The R,E&D effort will concern itself with eliminating, or at least minimizing these errors, and integrating the dependent surveillance reports on the radar controller's display.

It can be seen that dependent surveillance involves more than just surveillance reports. Navigation and communications are inherent characteristics of the technology that must be considered if the project goal is to be met. In addition, avionics technology will be involved in that improvements in accuracy and reliability are needed.

The R,E&D activity in this area will determine the performance of alternative ground-based navigation and communications systems being considered for automatic dependent surveillance. Since dependent surveillance compromises the historical separation of navigation and surveillance functions, it is imperative that a dependent surveillance system not be susceptible to single point failures. Specifications must be developed for acceptable systems. In addition, procedures must be developed for validating automatic dependent surveillance reports, and interfaces must be developed for incorporating information from satellite-derived navigation and communication sensors.

Surveillance Project Summary

Area	Project Number	Project Name
Ground-Based Independent Surveillance	6.1	Sensor Improvements
Ground-Based Independent Surveillance	6.2	Low-Altitude Surveillance
Ground-Based Independent Surveillance	6.3	Landing Monitor for Closely Spaced Runways
Ground-Based Independent Surveillance	6.4	Advanced Radar Technology
Surface Surveillance	6.5	Airport Surface Surveillance
Dependent Surveillance	6.6	Automatic Dependent Surveillance

6.1
Sensor Improvements

Purpose

To improve the detection, accuracy, and resolution of current FAA radar sensors; to develop new processing algorithms for different types of radar data; and to establish certification standards and procedures for new radars used in the terminal and en route ATC system.

Category

C—NAS Enhancement

Approach

Improvements to radar sensors will be aimed at those existing radars expected to be retained beyond implementation of the AAS, i.e., ASR-7/8 and Air Route Surveillance Radar (ARSR) -3. The goal is to develop a Moving Target Detector (MTD) similar to that of the ASR-9 that will provide detection of real targets and rejection of clutter targets in a clutter or heavy weather environment. ASR-7/8 MTD specifications will be based on ASR-9 test results. This capability is intended for all en route radars that are to be upgraded or replaced, including the new 2D and 3D radars. One ASR-7/8 site will be modified with the new MTD and tested prior to first operational installation.

Radar processing algorithms will be developed for two separate applications:

- Primary surveillance tracking for Mode S sensors when collocated with MTD-equipped radars—This effort will be based on the Mode S/Air Traffic Control Radar Beacon System (ATCRBS) correlation algorithm. MTD-measured characteristics, such as Doppler velocity, will be examined for use as correlation criteria. Candidate algorithms will be analyzed with simulated data prior to the evaluation of live MTD/Mode S data collected at the FAA Technical Center. Further refinements will be based on real-time data from ASR-9 sites. Implementation of the Mode S tracking algorithm is intended to be at the Mode S site. Specifications for primary surveillance tracking will be prepared for future sensor procurements and for a modification kit for delivered sensors.
- Multisensor processing to utilize all radar data available in multisensor coverage areas—This effort will follow a similar approach of simulation and testing once a baseline of current radar mosaicking performance has been established. Previous multisensor processing efforts will be used as a starting point for the definition of candidate algorithms. Multisensor processing is expected to be implemented in the AAS. Computer resource requirements will be defined based on results of tests with real-time data from Mode S and current en route and terminal radars conducted at the FAA Technical Center.

The new radars being procured—ASR-9, Mode S, 2D, and 3D—differ from radars currently in use in that they provide better positional accuracy and have only a digital output. Current radars, which will remain in the inventory for use with the AAS, must be upgraded to provide the same capabilities. The result is that present radar certification procedures and standards must be superseded by new standards that will reflect the new radar capabilities.

Products

- Specifications for incorporating MTD in the ASR-7/8 and the ARSR-3
- Test plans and procedures for MTD testing with ASR-7/8 and ARSR-3
- Specifications for Mode S primary tracking for future procurements
- Specifications for a modification kit for adding primary tracking to delivered Mode S sensors
- Test plan and report on Mode S primary tracker performance
- Specifications for the incorporation of multisensor processing into the AAS
- Test and implementation plans and procedures for multisensor processing
- Certification standards and procedures for new and upgraded radar systems

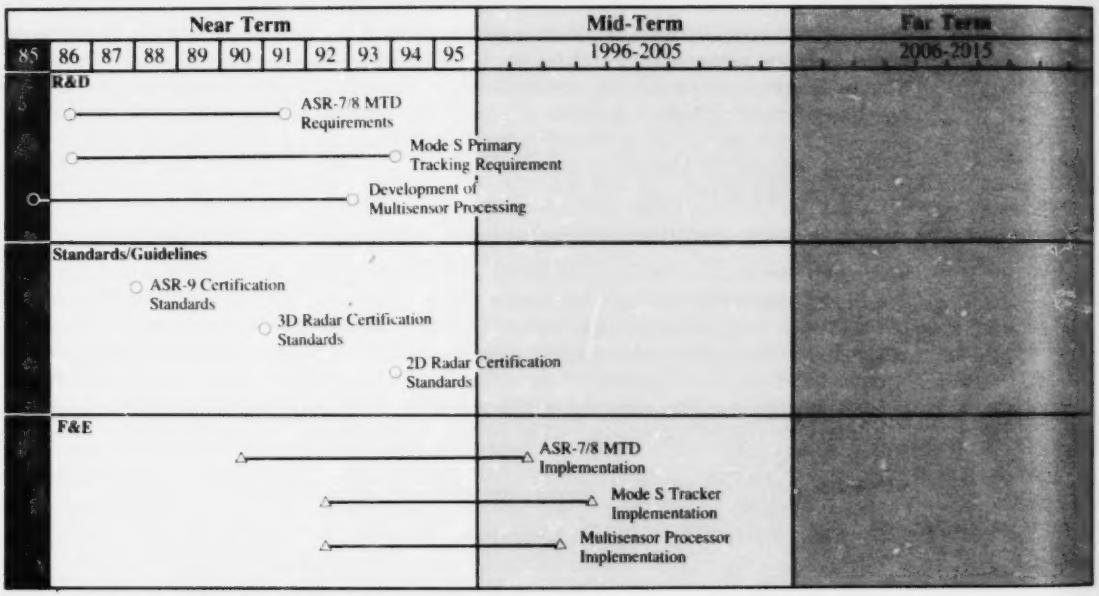
Recent Accomplishments

None

Related Projects/Activities

- Terminal Radar Program (NAS Plan)—the MTD developed for ASR-9 will be similar to those developed for ASR-7/8 and ARSR-3.
- Mode S/Data Link (NAS Plan)—Mode S sensor operational testing will be required for primary surveillance tracking algorithm development.
- Advanced Automation System—a multisensor processing algorithm will be implemented within the AAS software.

Schedule



6.2
Low-Altitude Surveillance

Purpose

To provide surveillance of rotorcraft and fixed-wing aircraft at low altitudes in airspace not adequately covered by existing en route and terminal facilities.

Category

C - NAS Enhancement

Approach

Low-altitude aircraft coverage is needed for heliports in high-density urban areas, certain remote areas, and offshore areas; neither ATCRBS nor Mode S will provide this coverage below 6,000 feet. To support the provision of separation services for these areas, requirements will be defined for low-altitude surveillance coverage. The system design will be based on the results of evaluations of primary and secondary radar systems and dependent surveillance systems.

One candidate system design to be investigated is a low-cost gap-filler radar/Mode S sensor. Among the items that must be considered in evolving the design are choice of frequency, clutter environment, maximum range, maximum altitude, target density, update rate, position accuracy, tracking accuracy, and need for remoting data.

Another candidate system design is a dependent surveillance technique using onboard navigation and communications avionics, similar to the low-altitude coverage currently provided for offshore aircraft by the Loran C Flight Following (LOFF) program. As part of this project, LOFF performance data will be analyzed. A system design will be developed for both the ground-based and avionics components. Tracking algorithms, display requirements, and interfaces with the radar controller's display will be included.

Specifications for the selected system design will be prepared for a prototype system, which will be implemented initially at an urban heliport. This prototype will be used to develop, test, and evaluate the hardware and software that are unique to this application. Following an evaluation of prototype performance, further applications will depend on a cost-benefit study.

Products

- Requirements definition for low-altitude surveillance coverage
- LOFF evaluation study report
- System design
- Prototype specification
- Test plans and procedures
- Cost-benefit study report

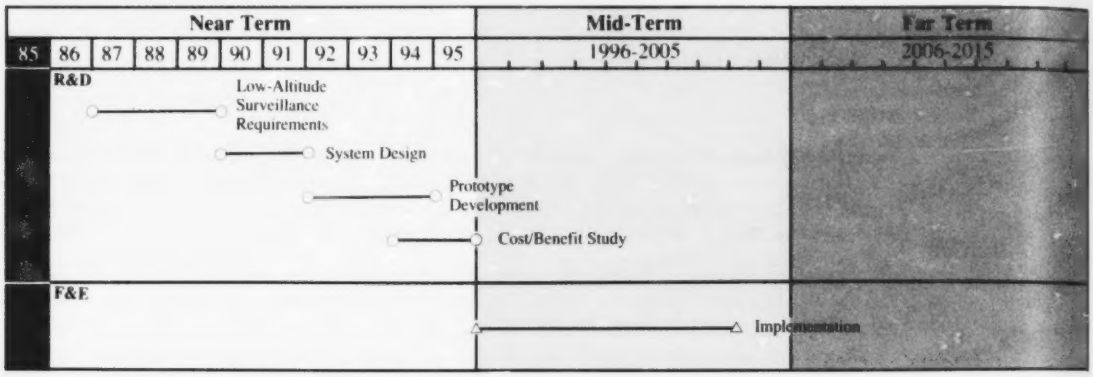
Recent Accomplishments

None

Related Projects/Activities

- Mode S/Data Link (NAS Plan)—provides the basic capability for identifying and tracking transponder-equipped aircraft.
- Terminal Radar Program (NAS Plan)—the MTD developed for ASR-9 provides the capability for detecting and tracking primary radar targets.

Schedule



6.3
Landing Monitor for Closely Spaced Runways

Purpose

To develop independent surveillance coverage of aircraft approaches and landings to support IFR operations on closely spaced parallel runways, triple runways, and converging runways in an effort to improve airport capacity.

Category

E—New Initiatives

Approach

The landing monitor developed by this project must provide the controller with sufficient accuracy, update rate, and display tools to respond to aircraft deviations and complex MLS approaches. Requirements will be determined for the accuracy and update rate needed for airport-based monitors and tower displays at candidate sites. Alternative concepts will be developed and evaluated, including the application of existing systems such as the Instrument Landing System (ILS) and Airport Surface Detection Equipment (ASDE), and new systems such as the Microwave Landing System (MLS) and Mode S that may be available soon.

Previous studies have indicated that for independent operation of closely spaced parallel runways down to 3400 feet separation, a surveillance radar with a 2 mrad beam width and a 2 second update rate (2 mrad/2 sec) is adequate. It is estimated that a 1 mrad/1 sec radar will be sufficient for reducing parallel runway separation down to 3000 feet. Specifications for a prototype system will be developed, and a prototype procured for testing and evaluation at sites to be selected. Technical feasibility and cost-benefit studies will be performed in the selection process. There will be a study of alternative, low-cost monitoring systems that could be used in place of radar to support airport capacity improvement programs. Operational procedures and guidelines will be established based on test results.

Computer requirements for additional processing will be determined and appropriate algorithms developed. It is anticipated that implementation of the tracking algorithm will be in the Tower Computer Control Complex (TCCC) until after the consolidation of Area Control Facilities (ACFs).

Products

- Operational requirements definition
- Technical feasibility and cost-benefit studies
- Prototype system specifications
- Test plans and procedures
- Operational procedures and guidelines

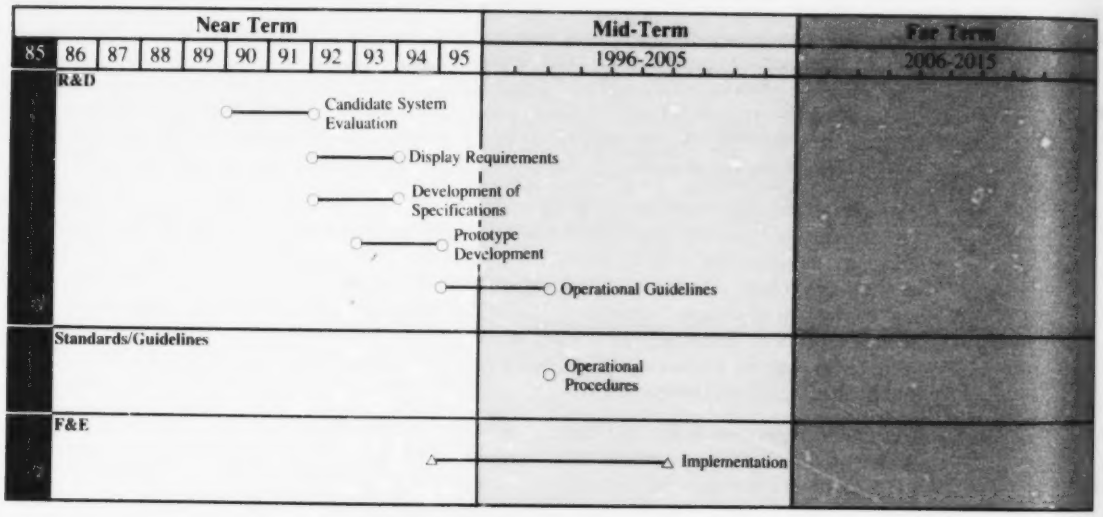
Recent Accomplishments

None

Related Projects/Activities

- Instrument Landing System (NAS Plan)—will be investigated for possible applications to a ILS landing monitor.
- Precision Approach and Landing—accurate landing guidance for closely spaced parallel and converging runways will depend on MLS application.
- Mode S Data Link Applications Development—data link may be used for aircraft identification, altitude, and position information.
- Airport Surface Surveillance—landing monitor will need extended surveillance coverage and aircraft identification on the airport surface, to and beyond the outer marker.
- Airport Capacity Improvements—preliminary studies will identify potential technological approaches for a landing monitor.

Schedule



6.4
Advanced Radar Technology

Purpose

To investigate, specify, and prototype, where feasible, advanced radar techniques and technologies that will improve surveillance coverage, target detection, and support of new ATC functions to be implemented in the AAS and AERA.

Category

E—New Initiatives

Approach

The technologies to be considered include fixed and rotating phased array radars for both primary and secondary surveillance, and over-the-horizon (OTH) radars. Application and cost-benefit studies will be performed on the use of these radars in ATC operations. When analysis shows promise, specifications will be written, and prototypes procured for testing and evaluation. Advanced radar techniques will also be considered, such as increasing the frequency of detection to improve track accuracy and reliability.

Studies of ways to meet at least 70,000-foot altitude surveillance coverage will be performed. In addition, techniques for the detection of aircraft made of composite materials will be investigated. Possible new radar developments may occur as a result of the various studies.

The use of primary radar height-finder data by the AAS is specified in the NAS Level II design documentation. This project will address the utility of height-finder data in AAS tracker/conflict algorithms.

Products

- Technical feasibility study reports
- Cost-benefit studies
- Prototype specifications for advanced primary and secondary radars
- Test plans and procedures for advanced radar prototypes
- Primary radar height-finder data study

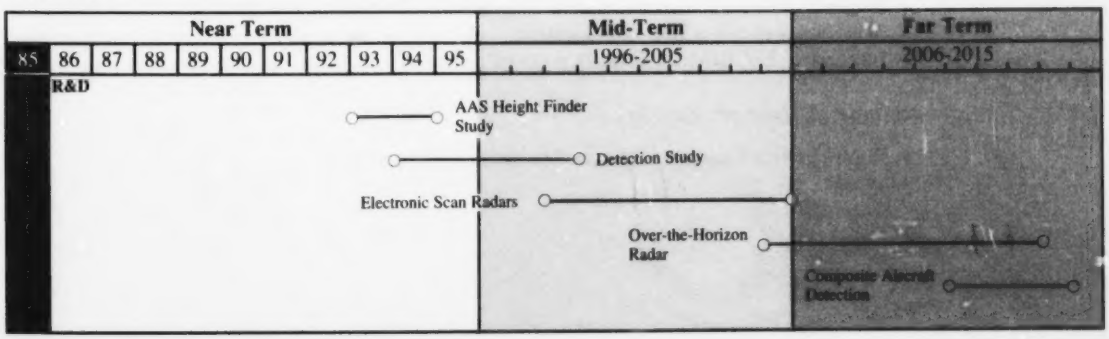
Recent Accomplishments

None

Related Projects/Activities

None

Schedule



6.5
Airport Surface Surveillance

Purpose

To provide automatic radar tracking and target classification for improved surface surveillance at airports equipped with ASDE radars, and to assess the feasibility of integrating data communications for the identification of Mode S transponder-equipped aircraft. At high-density airports, these improvements will reduce the heavy workload of air traffic controllers responsible for the movements of taxiing aircraft and supporting ground vehicles.

Category

C—NAS Enhancement

Approach

ASDE radars provide tower controllers at installed sites with a surveillance capability to monitor the movement of ground traffic in periods of limited visibility. This project continues the research aimed at developing enhancements to the ASDE radar to provide automatic radar tracking and target classification.

The activities of this project are focused on three primary objectives:

- Development of a target classification technique for ASDE data—An attempt will be made to develop a simple classification technique. The initial instrumentation capability may comprise a simple, perhaps nonscanning, system that will support the gathering of field measurements on a variety of targets. Output data from this radar will be recorded for subsequent use in the development and evaluation of techniques for classifying targets.
- Specifications of ASDE modifications for tracking targets automatically—Specifications for modifications to ASDE hardware and software will be defined that will improve detection accuracy and the ability to track targets automatically. Enhancements should also include the capability to network multiple ASDE installations.
- Feasibility assessment of Mode S integration to permit data communications for identifying targets—Several possible approaches for the integration of Mode S with ASDE will be investigated. Different configurations will be tested and evaluated at various locations using a surface measurements facility (SMF).

A transportable, integrated ASDE/Mode S testbed will be constructed and deployed to validate and demonstrate performance in a real-time mode. The resulting system will support both surveillance and data link communications on the airport surface. Part of the R,E&D activity will be the determination of whether a separate data link communications system for surface use would be needed at airports that will not receive an ASDE system.

Products

- System performance requirements in airport environment
- Specifications for ASDE modification
- Integrated ASDE/Mode S testbed

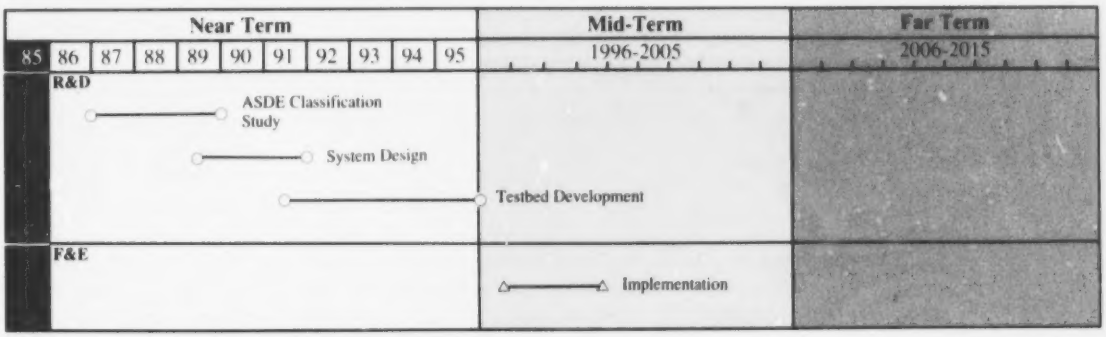
Recent Accomplishments

- Requirements analysis performed at Lincoln Laboratory.

Related Projects/Activities

- Airport Surface Detection Equipment (NAS Plan)—ASDE-3 radars will be installed at selected locations.
- Mode S Data Link Applications Development—the enhanced ASDE will be integrated with the Mode S data link so that the aircraft identifiers are consistent and data communications can occur for aircraft control.

Schedule



6.6
Automatic Dependent Surveillance

Purpose

To develop a dependent surveillance system that will automatically provide real-time position reports of equipped aircraft within the coverage area. The initial development will be for oceanic dependent surveillance coverage to increase airspace/air route capacity, improve traffic flow and fuel efficiency, and increase safety o transoceanic flights. The feasibility of using Automatic Dependent Surveillance (ADS) to augment and improv primary radar tracking in CONUS will also be investigated.

Category

E - New Initiatives

Approach

The development of an ADS system will be based on dependent surveillance techniques for aircraft position determination and reporting. A three-phase development approach is planned. Phase one will investigate the us of current avionics with a modified communications capability to obtain real-time aircraft position reports for controller display. The Oceanic Display and Planning System (ODAPS) will be used as a baseline for controller displays to aid in the initial development of oceanic ADS. A tracking algorithm will be developed, and the performance measured for different combinations of navigation and communication systems. Data link and display requirements will be determined based on an analysis of phase one system performance. Phase two will implement a modified system with improved avionics and automatic reporting. Avionics standards will then be developed. The third phase will develop an automated dependent surveillance function fully integrated with controller display operation. A safety analysis will be performed to identify and correct system design weaknesses affecting safety.

Investigation into the feasibility of using ADS tracking in conjunction with primary radar tracking (independen surveillance) will be performed at a test site where both systems are used separately. Comparisons will be made based on data accuracy and reliability. Results will be used for the prototype specification of a cooperative surveillance for possible CONUS application.

Products

- Requirements definitions for the detection, separation, navigation, and control of aircraft in oceanic airspace
- Tracker design for an oceanic system using dependent surveillance inputs
- Data link and display requirements for an oceanic control system using dependent surveillance inputs
- Technical standards for avionics
- Safety analysis
- Specifications for a phased oceanic control system
- Test plans and procedures
- Study reports on dependent surveillance improvements to independent surveillance
- Study reports on system comparisons
- Specification for prototype dependent surveillance system for CONUS application

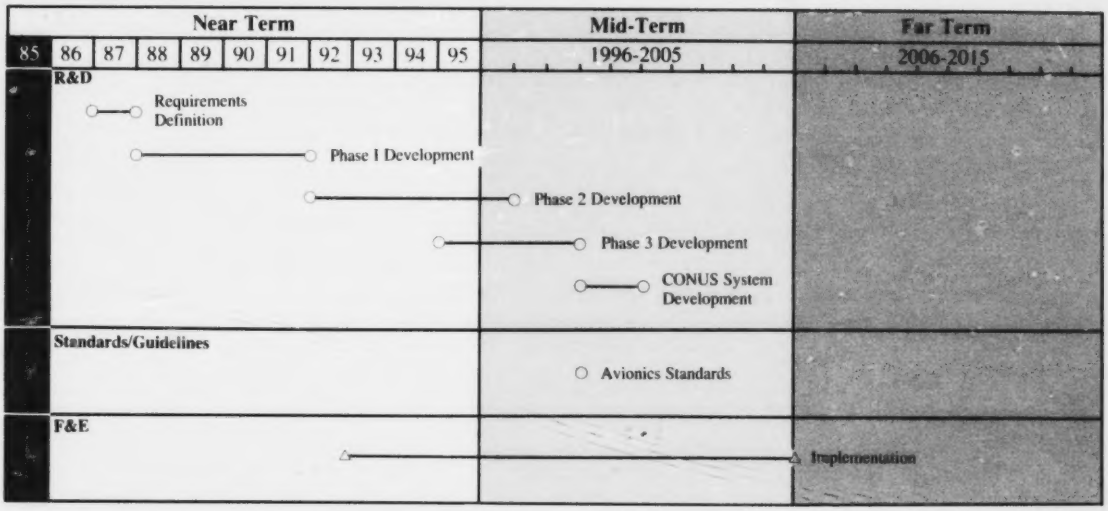
Recent Accomplishments

None

Related Projects/Activities

- Oceanic Display and Planning System (NAS Plan)—will provide a baseline for controller display and aids in oceanic ATC.
- Oceanic Display and Planning System Enhancements—will define display and surveillance requirements to be met by oceanic ADS.
- Traffic Alert and Collision Avoidance System—TCAS avionics will be analyzed for ADS application.

Schedule



Chapter 7
Weather Services

Weather service projects will evolve into a fully automated aviation weather system for more efficient use of the national airspace.

Weather is, and will continue to be, a critical factor in all flight operations. It is the single largest contributor to airport delays, and a major cause of aircraft accidents and incidents. The safe and efficient operation of the air transportation system mandates an efficient and effective aviation weather system. Different elements and the supporting equipment of the present system have evolved in response to the operational needs of the ever-growing air transportation system. Weather service users encompass the entire spectrum of flying, from the casual pleasure flyer to the operator of the most sophisticated, high-performance aircraft.

Routine weather data, such as surface weather observations, winds and temperatures aloft, and area forecasts, are required by pilots for strategic flight planning. Information on hazardous weather conditions, such as wind shear, gust fronts, thunderstorms, and poor visibility, is required for departure/landing decisions. In addition, pilots need information on severe weather, turbulence, and icing for en route tactical avoidance. Today's system is primarily a manual one, and consequently is both labor-intensive and constrained by voice communications. It frequently fails to serve fully the needs of all flight operations. The aviation weather system of the future, currently being developed, must provide precise weather information to NAS users.

Weather data acquisition, processing, and forecasting are primarily the responsibility of the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA). The FAA's primary role is to disseminate weather information to aviation users. The goals of the FAA's aviation weather system development program are as follows:

- To increase the frequency, accuracy, and temporal and spatial resolution of weather observations
- To improve the quality of weather analyses and forecasts, especially short-range forecasts
- To increase the efficiency of the distribution of weather information

The FAA can achieve these goals only through the cooperation and assistance of NOAA, NWS, other government agencies involved in weather activities, the aviation industry, and NAS users. The successful achievement of these long-range goals will ensure that the aviation community is provided with maximum safety and the ability to operate economically, with minimum impingement on free access to the nation's airspace.

The FAA has established a separate comprehensive plan for the development of the aviation weather system for the next decade. This plan—the Aviation Weather System Plan—has brought into focus the various operational and research and development programs that will directly support the achievement of the goals outlined above. It directly supports the planned NAS modernization and covers a phased development of the aviation weather system. Table II presents highlights of the improvements expected in the near term as laid out in the plan; it also presents a perception of future improvements in the mid- and far terms toward the evolution of a fully automated system for efficient use of the airspace in the future. The elements of this evolution are described below in the areas of data acquisition, data processing, and the distribution of weather information.

Data Acquisition

Weather observations encompass the entire field of assessment of atmospheric and meteorological conditions. Such an assessment includes the measurement of surface weather parameters and the visual examination of weather conditions; remote sensing of the upper atmosphere by radar, balloon sounding, and satellite; and detection and tracking of convective storms by radar.

Today, surface observations require a series of manual and labor- intensive tasks. A key development program jointly sponsored by the FAA, the NWS, and the U.S. Air Force (USAF) Air Weather Service will automate the process of acquiring surface observations. The FAA has developed and demonstrated the Automated Weather Observing System (AWOS), and has contracted for the production and installation of an initial 120 systems. This system measures the following seven parameters at one-minute intervals: direction and speed of wind, temperature, pressure as used in altimeter setting, precipitation, visibility, and cloud height up to 5,000 feet. The measured data are automatically processed and formatted for distribution. Data distribution can be either through computer-generated voice by radio broadcast or telephone, or through digitized data transmission by land-line or microwave link. The system can be operated in either an attended or unattended configuration and is of modular design so that additional sensors can be incorporated.

Table II
Evolution of Aviation Weather Systems

Area	Near Term 1986-1995			Mid-Term 1996-2005			Far Term 2006-2015		
	Improvement	R,E&D Project (Number)	Benefit	Improvement	R,E&D Project (Number)	Benefit	Improvement	R,E&D Project (Number)	Benefit
Data Acquisition	Improve quality and frequency of routine weather data through improved sensors and automation.	Weather Sensor Development (7.1)	S PP	Enhance sensors to provide improved measurement of cloud height and amount (layers) at higher altitudes and to identify and measure types of precipitation.	Weather Sensor Development (7.1)	S PP	Continue to support the development of sensors based on state-of-the-art technology to acquire accurate knowledge of upper atmosphere.	Weather Sensor Development (7.1)	S PP
	Develop Terminal Doppler Weather Radar for detecting wind shear and microbursts in terminal areas.	Terminal Doppler Weather Radar (7.3)	S PP	Improve timely detection and tracking of hazardous weather phenomena, including wind shear in a total wind shear environment (vertically and horizontally correlated).	Terminal Doppler Weather Radar (7.3)	S PP	Improve the resolution and accuracy of detecting hazardous phenomena in the airport areas.	Terminal Doppler Weather Radar (7.3)	S PP
	Enhance existing wind shear detection capabilities.	Low-Level Wind Shear Alert System (LLWAS) Enhancements (7.4)	S PP	Support the development of improved techniques for accurately measuring winds aloft up to FL600.	Weather Research Support (7.5)	S PP	Precisely identify areas/regions affected by weather disturbance.	Weather Research Support (7.5)	S PP
Data Processing	Provide automatically generated graphic and alphanumeric data for pilot route weather briefings. Provide real-time weather information: routine (alphanumeric) information on hazardous weather areas (graphics) to airborne pilots.	Weather Processing (7.6)	S PP UP	For consistency of information, develop a centralized data base of all weather products with automated input/output of weather information.	Centralized Weather Information Processing (7.7)	S PP UP	Develop a fully automated aviation weather system generating routine and hazardous weather products along each pilot-defined route and directly disseminating that information to the cockpit.	Centralized Weather Information Processing (7.7)	S PP UP
	Automatically provide to ground support personnel information on surface weather conditions and upper winds, and display of hazardous weather through reflectivity intensity contours.	Weather Processing (7.6)	S PP UP	Develop means of automatically processing airborne pilot requests for weather information. Provide concise direct read-outs in cockpit. Develop techniques for accurately predicting weather changes, movement of fronts and thunderstorms, and potential areas of weather hazards 4 to 5 hours in advance.	Centralized Weather Information Processing (7.7)	S PP UP			
Weather Information Distribution	Provide hazardous weather alerts to the controllers and airborne pilots. Develop technique for rapidly composing and broadcasting consistent and concise information on routine and hazardous weather.	Automated Hazardous Weather Warning/ Alert Capability (7.8)	S PP UP	Provide latest route-oriented information continuously in the cockpit. Use data link broadcast technique to warn airborne pilots of hazardous weather along their route of flight automatically.	Automated Hazardous Weather Warning/ Alert Capability. (7.8)	S PP UP	Provide means for continuous access to weather information (directly from the cockpit) to enable random route selection.	Automated Hazardous Weather Warning/ Alert Capability. (7.8)	S PP UP

C—Capacity
S—Safety
UP—User Productivity
PP—Provider Productivity

The systems being developed by the NWS and the Air Weather Service are similar in design and employ the same basic sensors. The automated surface weather observing systems developed in the near term will have limited sensor capabilities to measure cloud height and coverage (i.e., broken, overcast), and to identify types of precipitation. The FAA, NWS, and USAF will continue to enhance these sensors.

In the current system, the acquisition of upper air data is basically accomplished through balloon soundings—an expensive and labor-intensive method. For a number of years, NOAA has been developing new techniques and equipment for sounding the upper atmosphere. Engineering models of ground-based tropospheric microwave radar profilers, capable of measurements from the surface to approximately 60,000 feet (FL600), have been developed and tested. Satellite-based infrared radiometric sounders are also being evaluated. In the year 2000 and beyond, the NAS will be provided with accurate and current global upper air data from the combined deployment of these types of systems. The FAA is supporting the development of these systems. With the advent of world-wide air-ground digital data links, atmospheric measurements taken by aircraft will also be incorporated into both national and international meteorological centers and data bases.

Another joint program, involving the Departments of Transportation, Commerce, and Defense, is the development and deployment of the Next Generation Weather Radar (NEXRAD). This program is directed by a Joint System Program Office that is funded and staffed by the FAA, NWS, and USAF. NEXRAD prototypes are being fabricated by two competing contractors and will undergo full operational test and evaluation. A production contractor will then be selected. A nationwide network of radars that will meet the weather detection needs of the FAA, NWS, Department of Defense (DOD), and other government and private organizations will be deployed under this program.

Concurrently with NEXRAD development, the FAA has initiated a separate project for the development of a Terminal Doppler Weather Radar for detecting wind shear and hazardous weather in the immediate vicinity of an airport. The deployment of Doppler weather radars at major airports that are subject to frequent hazardous wind shear conditions and severe convective storm activity will supplement the en route coverage of the NEXRAD network, and greatly enhance the safety and efficiency of airport operations. Weather data provided by these radars will improve short-range forecasts of terminal conditions and provide real-time weather information to ATC facilities.

In the long run, research must be continued to permit the precise prediction of areas affected by weather hazards such as wind gusts, fronts, hurricanes, and severe turbulence. The wind shear detection system with enhanced capabilities will provide information on total wind shear environment.

Data Processing

Weather analysis and forecasting are primarily an NWS responsibility. The FAA establishes operational requirements for aviation weather services and products, and assists the NWS in the acquisition and distribution of basic weather data and finished products.

Aside from these specific responsibilities, the FAA is developing, in the near term, techniques and systems for providing automated, computer-generated short-range and route-oriented forecasts. The FAA is also participating in the national Stormscale Operational and Research Meteorology (STORM) program. This long-range research program is specifically aimed at developing mesoscale weather analyses and forecasts in near real time for operational applications. Additionally, it is anticipated that the Center Weather Service Unit meteorologists will play an expanded role in "nowcasting"—much along the lines of today's Center Weather Advisory service. Sophisticated weather data processors and interactive workstations are being designed to support aviation's need for the rapid transfer of information and high-quality forecasts.

Once the planned aviation weather system elements are in place, efforts will be required to develop a centralized data base of all weather products, as well as automated means for the input/output of weather information, so that consistency in the information available to users can be maintained. When fully automated, the system will generate routine and hazardous weather products for each pilot-defined route, and these products will be automatically disseminated to the cockpit.

Weather Information Distribution

The finest-quality forecasts and the most accurate weather assessments are of marginal benefit if they are not translated into information useful for the ultimate user, and if this information is not delivered to the user at the proper time. The majority of the FAA's investment in the planned aviation weather system is in the area of data handling and distribution. Near-term projects, such as the Central Weather Processor (CWP), Aviation Weather Processor (AWP), Weather Communications Processor (WCP), Mode S data link, National Airspace Data Interchange Network (NADIN), National Interfacility Communications System (NICS), and Weather Message Switching Center Replacement (WMSCR), are all designed to expedite the flow of information throughout the NAS.

In the mid- and far terms, FAA weather projects will address the integration of ever-increasing quantities of weather information into an advanced airspace management system. Weather services and products will be closely coupled to advances in telecommunications, satellite data distribution systems, and automated traffic management.

Weather Services Project Summary

Area	Project Number	Project Name
Data Acquisition	7.1	Weather Sensor Development
Data Acquisition	7.2	Next Generation Weather Radars
Data Acquisition	7.3	Terminal Doppler Weather Radar
Data Acquisition	7.4	Low-Level Wind Shear Alert System Enhancements
Data Acquisition/Data Processing	7.5	Weather Research Support
Data Processing	7.6	Weather Processing
Data Processing	7.7	Centralized Weather Information Processing
Information Distribution	7.8	Automated Hazardous Weather Warning/Alert Capability

7.1
Weather Sensor Development

Purpose

This project (1) evaluates new systems and techniques for the measurement of surface weather parameters, (2) tests the capabilities of improved weather sensors, and (3) supports research studies on weather conditions that are hazardous to flight operations.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

In the near term, the FAA is developing and deploying a limited number of Automated Weather Observing Systems (AWOSs). This system provides minute-by-minute measurements of seven weather parameters: wind speed and direction, temperature, pressure as used in altimeter setting, precipitation, visibility, and cloud height up to 5,000 feet. The system will be deployed at uncontrolled airports where instrument approaches have been approved and no weather observations are taken. The system specification will be available to non-Federal agencies and airport operators who wish to procure such systems. AWOS will be qualified for the Airport Improvement Program.

In addition to R,E&D activities called for in the NAS Plan, advanced weather sensor development conducted primarily by NOAA laboratories and the NWS, and supported by the FAA, will continue through the near term and into the mid-term. Sensor technologies and systems to be developed and evaluated include the following: (1) laser and infrared forward scatter and back scatter meters, (2) cloud height indicators or ceilometers for cloud measurements above 5,000 feet, (3) laser-based weather detectors that can discriminate between hydrometeors—like rain—and lithometeors—like dust—and can measure the associated precipitation rates, (4) lightning detection systems, (5) tropospheric microwave radar profilers for upper air measurements, and (6) evolving technologies for the detection and measurement of icing and clear air turbulence. Test and evaluation of advanced visibility sensors for measuring slant visual range (SVR) will be conducted in the mid-term.

Products

- Test reports and specifications for advanced weather sensor systems
- Test reports and specifications for AWOS and potential enhancements
- Test reports and specifications for runway visual range (RVR)/SVR systems

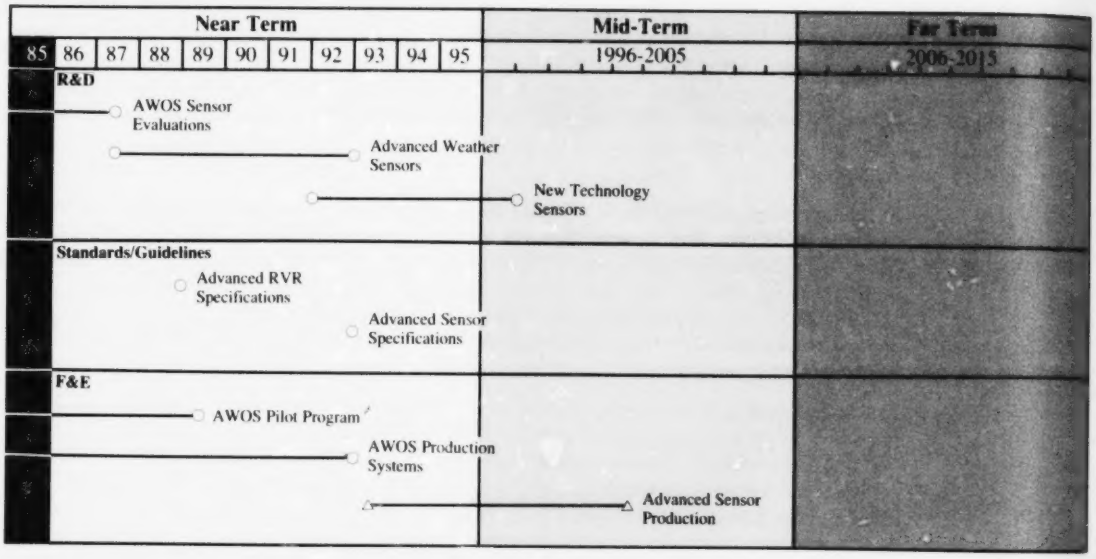
Recent Accomplishments

- Prototypes of an AWOS, based on commercially available components, demonstrated and evaluated in 1983-84.

Related Projects/Activities

- Automated Surface Observing System (NWS) and Advanced Automated Weather Observing Station (DOD) being developed under the Joint Automated Weather Observation Program (JAWOP) Council—will develop automated sensors for accurately measuring surface observation data.

Schedule



7.2
Next Generation Weather Radars

Purpose

To define and develop a new generation of Doppler weather radars that will provide accurate information on precipitation, reflectivity, wind velocity, and turbulence. To furnish software algorithms to take advantage of the improved radar presentation for weather data.

Category

B—Direct Support of NAS Plan

Approach

To improve hazardous weather detection, reduce flight delays, and improve flight planning, the FAA has joined with the NWS and the U.S. Air Force's Air Weather Service in a program designed to develop and deploy the Next Generation Weather Radar (NEXRAD) system. In general terms, NEXRAD requirements can be broken out into five areas: detection, signal processing, weather product generation, display, and reliability/maintainability. It is required that the NEXRAD system have sufficient sensitivity to detect very weak signals, such as those from gust fronts in the absence of precipitation, and to detect light-to-moderate precipitation from a distance of about 200 miles. In the signal processing area, NEXRAD is required to eliminate any signals that could contaminate the measurement of weather phenomena; such contaminating signals include ground clutter, as well as interference from other radars, aircraft, birds, and automobiles. For weather product generation, the NEXRAD system uses basic weather measurements made at different elevation angles to provide accurate indicators of the presence of hail, turbulent areas, tornadoes, and gust fronts. The FAA is also developing a Central Weather Processor (CWP) for the distribution and display of NEXRAD data; the CWP will collect data from many NEXRAD systems and mosaic these data into a single composite picture for FAA users. NEXRAD reliability/maintainability requirements ensure that the system will fail rarely and that when it does, it can be repaired in less than 30 minutes with the help of automated diagnostics.

The FAA intends to use NEXRAD to provide hazardous and routine weather radar data for all altitudes above 6,000 feet throughout CONUS, except over mountainous areas in the Western U.S., where the lower altitude will be 10,000 feet. Weather radar coverage will also be provided for selected areas in Alaska, Hawaii, and the Caribbean.

NEXRAD provides several aviation weather products related to winds, wind shear, turbulence, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, icing conditions, mesocyclones/tornadoes, and hurricanes. Meteorological algorithms exist for many of these products, and the FAA is devoting considerable research activity to the development of wind shear and icing algorithms. Further R,E&D efforts may be required for the validation and enhancement of algorithms needed to meet the requirements of weather products for ATC, including the weather radar data needed for the CWP.

Products

- Specification, prototype, and test reports for NEXRAD

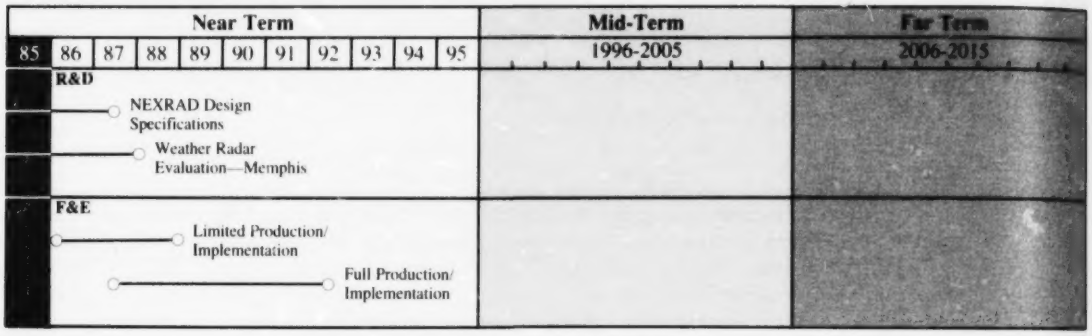
Recent Accomplishments

- Weather radar support facility established at Memphis, Tennessee for data acquisition, development of meteorological algorithms, and evaluation of radar performance.

Related Projects/Activities

- Central Weather Processor (NAS Plan)—will distribute weather radar data.
- Automated En Route ATC and Traffic Management—will utilize the improved data to provide advanced ATC automation.

Schedule



7.3
Terminal Doppler Weather Radar

Purpose

To define and develop a Doppler weather radar that will improve the detection and identification of dangerous wind shear and other hazardous weather events by measuring wind fields in the terminal environment.

Category

C—NAS Enhancement

Approach

Terminal Doppler Weather Radar (TDWR) will be developed for weather detection at airports; it will be similar to, and possibly a derivative of NEXRAD. Technical specifications, such as scanning rates and strategies, data update rates, fully automatic generation of radar products, ground clutter suppression, and controller display interface, will be developed. These radars will be deployed at major airports that experience frequent occurrences of hazardous wind shear conditions and severe thunderstorms.

Research will be continued on microburst-type wind shear detection by Doppler radar techniques. Data will be acquired for different elevation angles, scan techniques, precipitation levels, and environments. Wind field patterns and signal levels will be analyzed to determine signatures of dangerous wind shear events. Algorithms will be developed to identify the hazard locations and characteristics, and to provide guidelines for controller and pilot actions. A wind shear detection system using TDWR will be demonstrated at an airport.

Products

- Wind shear event analysis of TDWR data
- Detection and identification algorithms for wind shear
- Specifications and operational guidelines for TDWR
- Wind shear detection system using TDWR

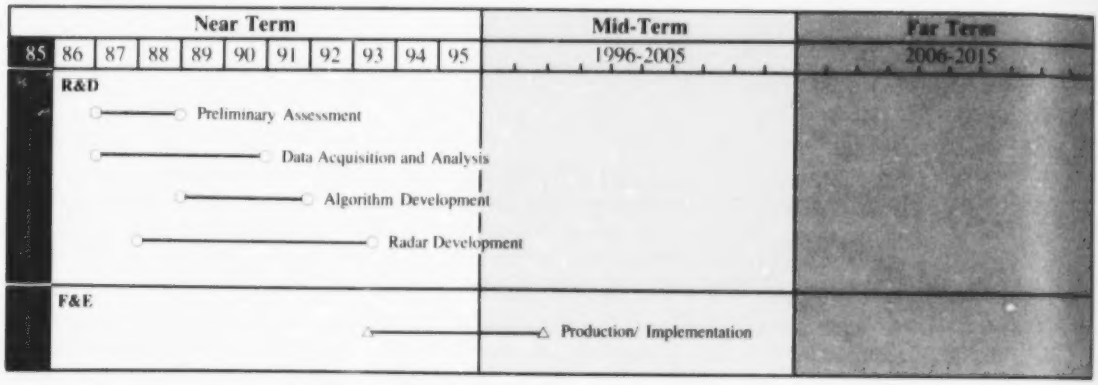
Recent Accomplishments

- Detection of precipitation and clear air wind patterns by Doppler radar demonstrated.
- Detection of microbursts by Doppler radar demonstrated.

Related Projects/Activities

- Low-Level Wind Shear Alert System Enhancements—provides research with respect to increased detection probability, reduced false alarms, improved interpretability, and procedures for identifying hazard characteristics of wind shear.

Schedule



7.4
Low-Level Wind Shear Alert System Enhancements

Purpose

To improve the wind shear identification performance of the Low-Level Wind Shear Alert System (LLWAS) with respect to increased detection probability, reduced false alarms, and improved interpretability, and to develop procedures based on the identified hazard characteristics.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

LLWAS anemometer network wind velocity readings will be recorded during wind shear events, and analyzed for purposes of developing wind shear detection criteria. Algorithms will be developed that will make recommendations to the controller on runway usage and possible waveoffs necessitated by the hazard. These algorithms will be evaluated for their operational effectiveness. Appropriate displays will be developed that will enable a controller to quickly evaluate the hazard and the recommended actions. Operational procedures will be developed for rapid and appropriate response by controller and pilot in case of a dangerous wind shear event. These R,E&D activities planned for LLWAS enhancement are not included in the current NAS Plan project for enhanced LLWAS development.

Products

- LLWAS wind shear event data analysis
- LLWAS wind shear detection and identification algorithms
- LLWAS operational guidelines
- LLWAS display specifications
- Enhanced LLWAS system specification
- Evaluation of enhanced LLWAS system

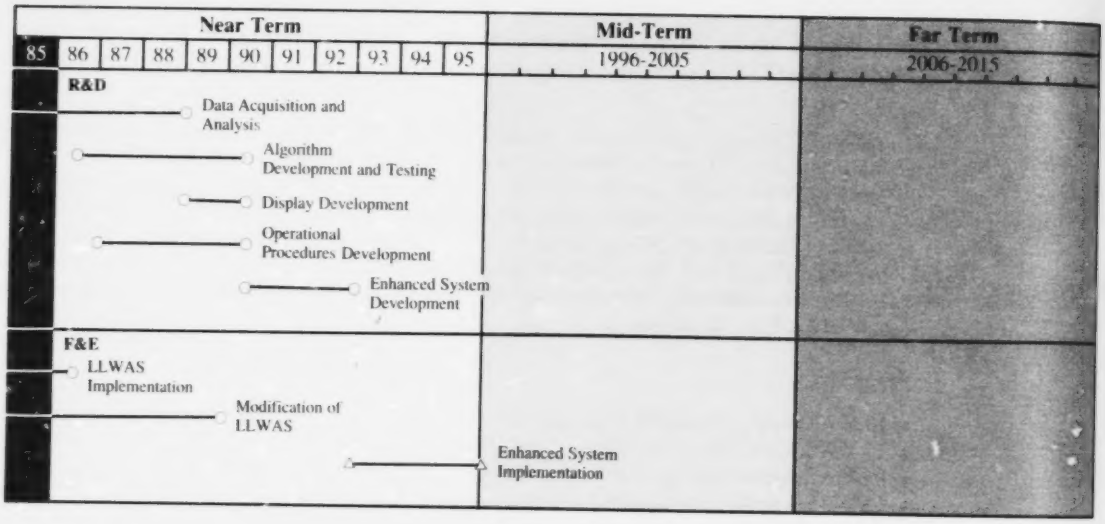
Recent Accomplishments

- Preliminary anemometer data analysis completed.

Related Projects/Activities

- Wind Shear Efforts (NAS Plan)—will develop wind shear models based on data collected in the Joint Airport Weather Studies (JAWS) program.
- Advanced Wind Shear Sensor Development—provides research on measurement of wind fields using advanced technology sensors.
- Airborne Doppler Radar Wind Shear Detection (joint NASA/FAA program)—will develop a technique for airborne detection of wind shear and prediction of aircraft response.

Schedule



7.5
Weather Research Support

Purpose

To foster and promote basic weather research by providing the FAA with resources to support other Government agencies and, in some cases, private institutions and industry.

Category

D—Sustaining R,E&D Activities

Approach

The FAA will support, on a limited basis, other organizations that are engaged in basic weather research, such as NOAA Laboratories, the National Science Foundation and its associated entities, NWS centers and laboratories, and NASA. Programs such as the National Stormscale Operational and Research Meteorology (STORM) program, Microburst and Severe Thunderstorm (MIST) experiments, and the Genesis of the Atlantic Low Experiment (GALE) will investigate weather and atmospheric phenomena and anomalies that have an impact on aviation safety. The FAA perceives a critical need for improvements in the areas of short-term forecasting; icing and turbulence forecasting; quality, quantity, and frequency of upper air measurements and forecasts; and in a general sense, the collection and assimilation of weather data. The FAA also strongly recommends research into the detection and identification of hazardous weather precursors. The recognition and tracking of mesoscale atmospheric disturbances, or anomalies such as severe thunderstorms, heavy rain or hail, tornadoes, and hurricanes that spawn severe convective storm complexes, will ensure the safety of flight operations and contribute to efficient airspace management.

Products

- Research studies and reports on improved techniques for forecasting winds, low-level wind shear, turbulence, hazardous convective storms, and aircraft icing that will serve to expand the knowledge base on the atmosphere

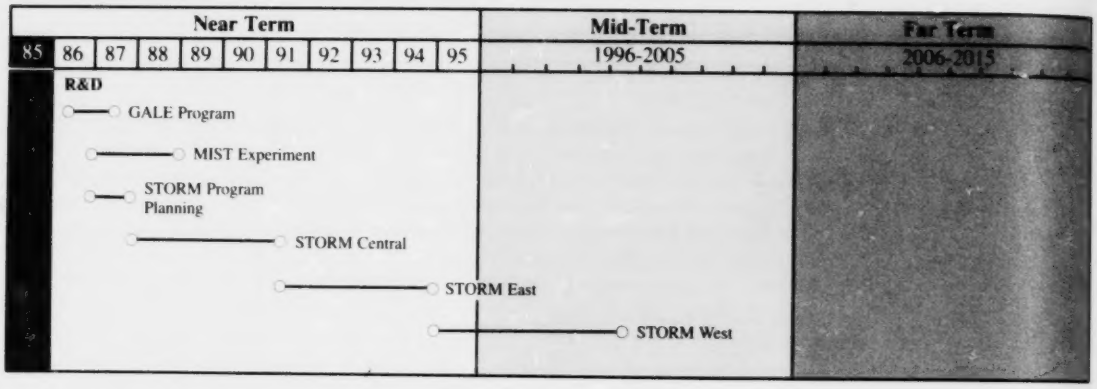
Recent Accomplishments

None

Related Projects/Activities

- Doppler Light Detection and Ranging (NASA)—will provide measurements of upper atmospheric winds.
- Airborne Wind Shear Program (NASA)—will explore new technologies for development of a practical airborne detector of wind shear.
- Weather Radar Program (NAS Plan)—will develop a Doppler radar capability for STORM and other related weather research.

Schedule



7.6
Weather Processing

Purpose

To develop, test, and evaluate a computer system and software that will process and disseminate near real-time weather information throughout the NAS. This project will also improve weather information and short-range forecasts provided to controllers, flight specialists, and aircraft operators. These system forecasts will improve the efficiency of air carrier, general aviation, and rotorcraft operations by reducing weather-related delays and accidents.

Category

B—Direct Support of NAS Plan

Approach

The Central Weather Processor (CWP) is being developed and enhanced by this project and will have the following principal functions:

- To process weather radar data obtained from NEXRAD and various other radar sources for direct use by Area Control Facility (ACF) controllers, Flight Service Specialists, and pilots.
- To provide automation support for the ACF Center Weather Service Unit (CWSU) workstation. This support will provide the meteorologist with access to all the necessary meteorological observations, such as weather radar, satellite, surface, and upper air, and with a library of operational algorithms that may be used to produce value-added weather products for use by the ACF controllers and the Automated Flight Service Station (AFSS). The CWP will interface with the Advanced Automation System (AAS), the Flight Service Automation System (FSAS), the Flight Service Data Processing System (FSDPS), and the Weather Communications Processor (WCP) serving the Mode S data link.

Specifications will be written, and an engineering model will be used to investigate the various automation aids and output products, such as severe weather contours, as well as the data link products. Production specifications will be written following operational test and evaluation of the prototype system.

Concurrent with the serial development of engineering and prototype models will be the development of enhancement packages to the basic system. These packages will accommodate new weather sensors and NAS modernization elements currently under development, such as NEXRAD, the AAS, and others. Cost-effectiveness studies will be made of the use of new sensors, such as TDWR and selected existing nonstandard sensors, and the integration of advanced automation capabilities, such as the Mesoscale Analysis and Prediction System (MAPS) being developed by NOAA/PROFS (Program for Regional Forecasting and Observing Services). In addition, interfaces will be developed to meet new requirements that become part of the baseline NAS design. The basic system will be able to accept and integrate these enhancement packages. Test demonstration and evaluation of the enhancement packages will be conducted with the support of NOAA, the NWS, and the Environmental Research Laboratory (ERL).

Products

- Prototype and production specifications
- Test results and enhancement packages

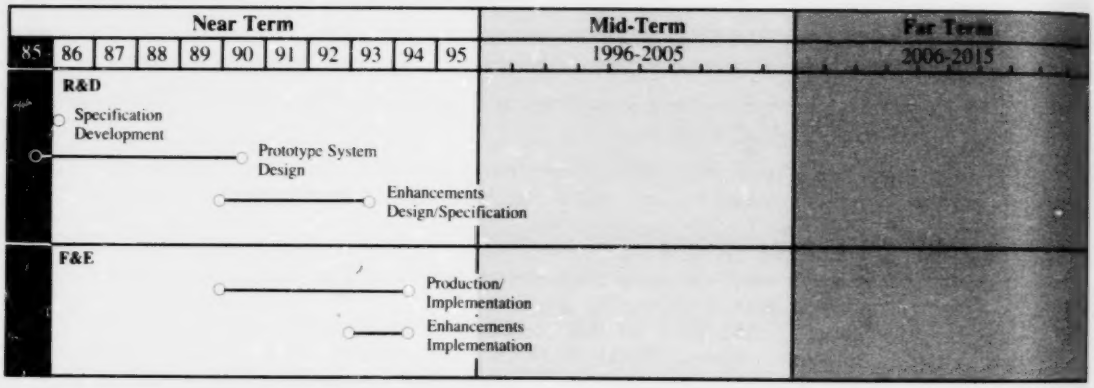
Recent Accomplishments

None

Related Projects/Activities

- Weather Radar Program (NAS Plan)—will provide hazardous weather information.
- Automated Weather Observing System (NAS Plan)—will provide automated weather observing capabilities.
- Automated Surface Observation System (NWS)—ASOS will provide automated surface weather observations.
- Mode S/Data Link (NAS Plan)—will be used to receive pilot weather reports from the aircraft.
- Advanced Automation System (NAS Plan)—will process the Pilot Reports (PIREPs) received through the data link for use by the CWP.
- Weather Message Switching Center Replacement (NAS Plan)—will be used for weather product exchange between the CWP and NWS systems.

Schedule



7.7
Centralized Weather Information Processing

Purpose

To develop an integrated weather data base for generating a consistent and machine-readable set of alphanumeric and graphic products.

Category

C—NAS Enhancement

Approach

The key to centralizing weather information is the need to separate data entry from product generation in weather processing. The following activities will be carried out:

- Identification of all sources of weather information, such as observations, sensor data, and forecasts, as potential inputs to a central processing system
- Definition of an integrated database structure for the storing and rapid distribution of all the information
- Definition of all machine-readable products that will be generated
- Definition of a rigorous set of algorithms that can be used to generate the above products

Products

- A centralized data base
- A standardized series of weather products
- A set of algorithms for generating these products

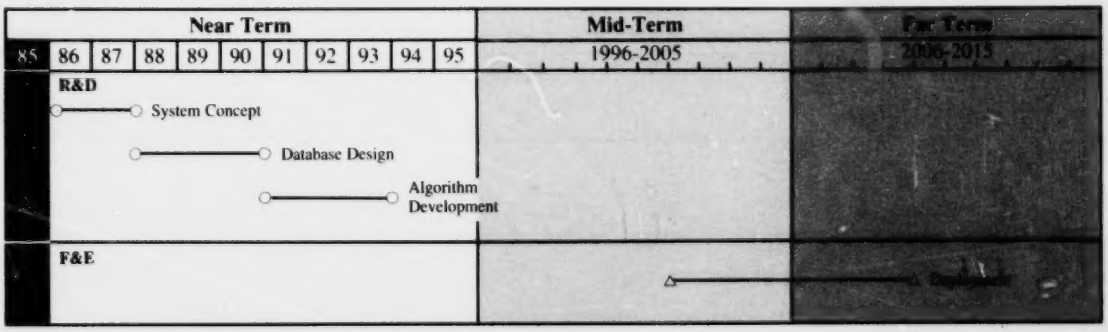
Recent Accomplishments

None

Related Projects/Activities

- Flight Service Automation System (NAS Plan)—will develop the Aviation Weather Processor (AWP) and Flight Services Data Processing System (FSDPS) within the Model 2 FSAS to provide the capability for pilots to access weather data via direct user access terminals.
- Weather Message Switching Center Replacement (NAS Plan)—will function as gateway to NWS and NMC for aviation weather data requirements.

Schedule



7.8
Automated Hazardous Weather Warning/Alert Capability

Purpose

To integrate various sources of hazardous weather information into an automated system for warning pilots and specialists of any hazardous weather conditions that may exist along a proposed flight path.

Category

C—NAS Enhancement

Approach

This project will combine hazardous weather information from a number of different sources to form a single data base from which automation equipment can provide a route-oriented hazardous weather forecast for individual flights. Techniques will be developed for automatically providing this information to pilots so that they can choose alternate routing, and to ATC controllers as an aid in their planning for possible flight amendments. An important part of the project will be the development of suitable human factors interfaces for communicating the information, and procedures for the use of data links by the pilots.

Products

- Hardware and software enhancements to the AAS incorporating new sources of weather data
- Procedures for disseminating information to pilots and controllers

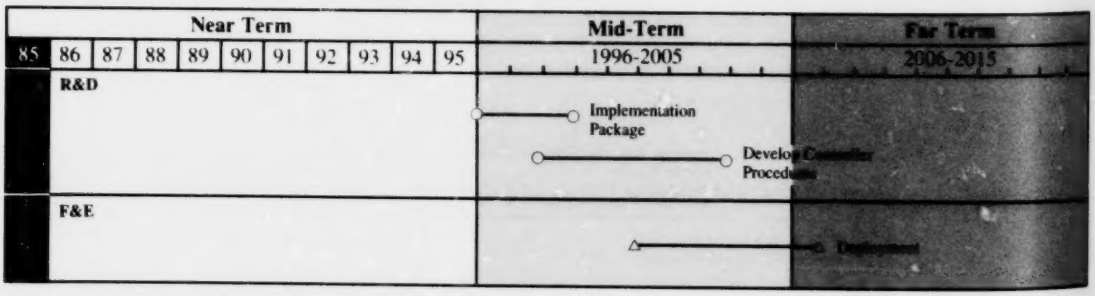
Recent Accomplishments

None

Related Projects/Activities

- Weather Radar Program (NAS Plan)—will provide information on hazardous weather conditions; the radar data will be processed by the CWP, and transmitted to the pilots via Mode S data link.

Schedule



Chapter 8
Satellite Applications

Satellite applications projects will support the decision process for evaluating the role of satellite technology in providing communications, navigation, and surveillance services.

Satellite systems have the potential for providing communications, navigation, and surveillance (CNS) services for civil aviation on a global basis. With the maturing of satellite technology, there has occurred a substantially increased interest in satellite systems, although questions remain concerning their economic and transition viability. The projects described in this chapter support the decision process regarding this technology by providing better-informed judgments about the proper role of satellite technology in CNS services for civil aviation.

The principal advantage of satellites, especially those in high-altitude orbits, is that they provide excellent line-of-sight coverage over very large areas to aircraft flying at low altitudes, and over remote land and oceanic regions of the earth. The Department of Defense's (DOD's) Global Positioning System (GPS) provides a near-term opportunity for extending the navigation services offered to civil aviation. This system will consist of 18 satellites and 3 active spares uniformly distributed in 6 orbital planes at an altitude of 10,900 nm. The GPS satellite constellation will provide signals in space that will allow properly equipped aircraft to determine their position and velocity in three dimensions. Additionally, GPS will provide time information. The accuracy of GPS position determination is substantially better than that currently available from other systems.

The introduction of satellite services into the future NAS will depend upon many factors, including the validation of user requirements, costs and performance characteristics, and service availability schedules. A number of groups have been chartered to investigate the opportunities satellite systems offer the ATC system of the future. Radio Technical Commission for Aeronautics (RTCA) Special Committee (SC)-155 was initiated in early 1984 to assess future CNS requirements and system concepts. Early in 1986, this group plans to provide recommendations to the FAA for consideration in the development of future ATC services. The International Civil Aviation Organization (ICAO) Future Air Navigation Systems (FANS) Committee will evaluate the application of satellites and other forms of advanced technology to global air traffic management systems of the future. Additionally, the FAA recently convened a special task group to provide an FAA assessment of satellite concepts and frequency spectrum requirements. This group completed a report that was published in February 1985 and has been adopted as an FAA position in the ICAO FANS activity. These investigations have provided a preliminary perspective on the system scenarios that can be used in the examination and development of generic CNS system options for the future.

For purposes of the R,E&D Plan, satellite applications have been concentrated into three project areas:

- Utilization of GPS for civil navigation in the near term
- Development of an overall satellite-based CNS system architecture and design
- Technical and economic studies to support the satellite-based CNS system design process

Utilization of GPS for Civil Air Navigation

This project will provide analysis, testing, system design recommendations, avionics standards development, and operational/technical requirements statements necessary to allow the full civil utilization of GPS. The operational applications to be addressed include supplemental and sole means for navigation, and nonprecision approach. This effort includes operations in oceanic, low-altitude, offshore, and remote area airspace. Under this project, the FAA will perform operational tests and evaluations in support of the development of the ATC procedures and avionics standards necessary to utilize GPS in the near term.

Satellite-Based CNS System Design Configuration

Using a systems approach, the FAA will conduct a comprehensive study aimed at determining the most effective applications of satellite technologies for CNS services in the future. This study will begin with a validation of operational requirements (FAA, RTCA SC-155, National Airspace Review, and others) and the development of functional requirements; this will be followed by an examination of technical concepts, including an analysis of their costs, benefits, and availability schedules. The results of these analyses will be used as a measure of the reasonableness of the requirements, and the subsequent addition, deletion, or modification of requirements will be coordinated with their original sponsors. A recommended CNS system architecture and designs will be developed on the basis of the adopted CNS requirements and available satellite-based techniques projected for the near, mid-, and far terms. This effort will provide the FAA with an evolving framework and road map for incorporating satellite technology into the NAS. The system design process will be

dynamic in that it will be adjusted as changes occur in user requirements, technology, and costs. This project will address the expansion of CNS services to oceanic airspace and to low-altitude, offshore, and remote regions on a national and global basis. It also encompasses institutional and transition issues, such as ownership/operator relationships and international coordination. The work of RTCA SC-155, prior FAA investigations in these areas, and the report of the FAA special task force on the assessment of satellite concepts and aviation spectrum requirements will serve as points of departure for this study.

Studies of CNS System Design Alternatives

This project will include a comprehensive study of various CNS applications and satellite-based techniques that will have the potential for supporting the design and implementation of an overall CNS system. For each of the three general areas—communications, navigation, and surveillance—investigation, analysis, and preliminary design studies will be performed concerning technical characteristics, development schedules, and costs associated with related applications. Representative applications for which satellite-based techniques will be examined include interfacility communications (CONUS backup and outside CONUS), domestic integrated voice/data links, alternate concepts for navigation, automatic dependent surveillance, and independent surveillance.

Satellite Applications Project Summary

Area	Project Number	Project Name
Navigation	8.1	Utilization of GPS for Civil Air Navigation
CNS Systems	8.2	Satellite-Based CNS System Design Configuration
CNS Systems	8.3	Studies of CNS System Design Alternatives

8.1
Utilization of GPS for Civil Air Navigation

Purpose

The purpose of this project is to support the utilization of GPS in the NAS. GPS has the potential for providing supplemental or sole means en route navigation services, as well as nonprecision approach navigation services, on a global basis.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

FAA approval for the civil use of GPS either as a supplemental or sole means air navigation system requires that the system satisfy all applicable requirements. It is necessary to evaluate GPS performance and resolve relevant issues, such as integrity and coverage reliability, before GPS can be introduced and used effectively in the NAS. The phase-in process for GPS will occur in progressively more demanding applications, ranging from en route navigation to nonprecision approach guidance. This process will involve tests and evaluations of the available satellite constellation, laboratory simulations, and analytical studies. The initial activity will be directed at using GPS as a supplemental means for navigation. The key issues are the quantification of system performance and development of an integrity monitor for interim use while GPS evolves into a sole means navigation system. Flight tests will be conducted in actual or simulated environments representative of the application under investigation, using available GPS receivers. Based on the results of the tests and evaluations, performance standards and certification guidance will be developed for the user avionics equipment.

As a supplemental means for navigation, GPS should have a minimal impact on existing systems, standards, and operational procedures. However, for the adoption of GPS as a sole means navigation system, more stringent integrity and coverage reliability requirements will need to be satisfied. Alternative ground-based or space-based control and monitoring concepts that alert users when performance is out of tolerance will be investigated. Selection of a recommended concept will be based on comparative assessments and trade-off analyses, such as capability vs. cost. An engineering model of the control monitor and necessary communications links will be developed and tested, and a technical specification prepared.

Techniques such as differential navigation using GPS may allow further application of GPS as an approach and landing aid, especially for currently nonequipped airports. The potential uses and value of differential GPS will be identified and assessed relative to user requirements and economic concerns.

This project also involves support to the development of standards and other technical documentation for the application of GPS for civil air navigation. Documents to be developed include National Aviation Standards, Minimum Operational Performance Standards (MOPS) for avionics, and avionics certification guidance. These R,E&D activities planned for GPS utilization are not included in the current NAS Plan project for GPS monitors.

Products

- Specifications of recommended technical and operational design characteristics for the user equipment, the ground control/monitoring system, and other appropriate elements as a function of the following operational applications:

  En route navigation
  - Supplemental
  - Sole means

  Nonprecision approach
  Approach and landing aid

- Reports presenting cost-benefit assessments and recommended guidelines for integrating GPS into the NAS as a function of the operational applications

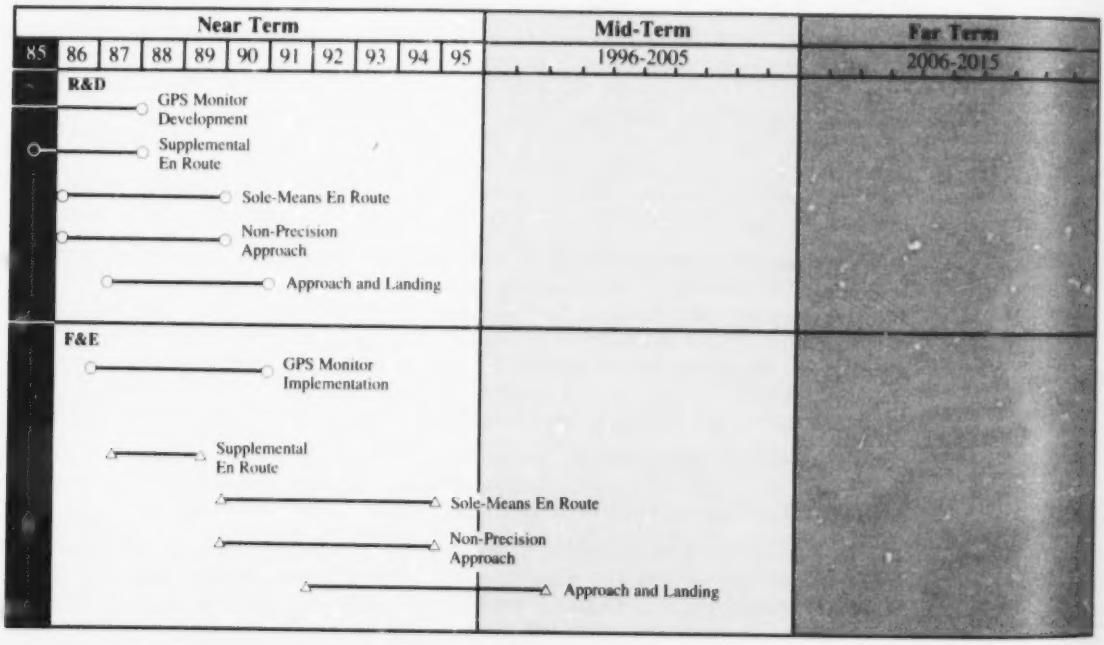
Recent Accomplishments

- Participated in joint industry/government task group to expedite operational integration of GPS into the NAS.
- Joint DOT/DOD policy statement on use of GPS published.

Related Projects/Activities

- Area Navigation—will include an assessment of performance variance between GPS avionics and other types of avionics used for RNAV.
- Helicopter Satellite Based Guidance—Differential GPS (NASA-Ames)— will evaluate the use of GPS to provide guidance to civil helicopter precision approach and landing with a ground signal used to improve accuracy.

Schedule



8.2
Satellite-Based CNS System Design Configuration

Purpose

To develop a recommended satellite-based CNS system architecture and design configuration as a function of implementation period and application.

Category

E—New initiatives

Approach

A systems approach will be used to develop a system framework for the application of satellite-based CNS techniques to the NAS. The design will begin with a validation of user requirements for CNS services. Interfacility and air-ground communications requirements for both voice and data will be addressed. These requirements will be analyzed as a function of region of usage, including CONUS; low-altitude, remote, and oceanic areas; and worldwide. Other functional CNS applications to be investigated include dependent and independent surveillance, navigation, and precision approach. In particular, user requirements that will be addressed in addition to those being met by the current NAS Plan account for such factors as the line-of-sight limitations of the ground-based CNS systems.

The requirements being addressed will be analyzed against various candidate satellite-based concepts through an assessment of technical characteristics such as spectrum requirements, risk, cost, benefits, and projected implementation schedules. The analysis will include an assessment of transition and institutional issues, such as ownership/operator relationships and international coordination (e.g., ICAO). The application of satellite-based CNS operations to existing CNS services and their impact on those services will be addressed as well.

The final product of this activity will be a recommended CNS system design configuration that supports a framework and road map for the planning, development, and implementation of satellite-based CNS services. This configuration will be dynamic in that it will be modified and updated as changes occur in technology and user requirements.

Products

- Requirements validation report
- CNS system configuration document

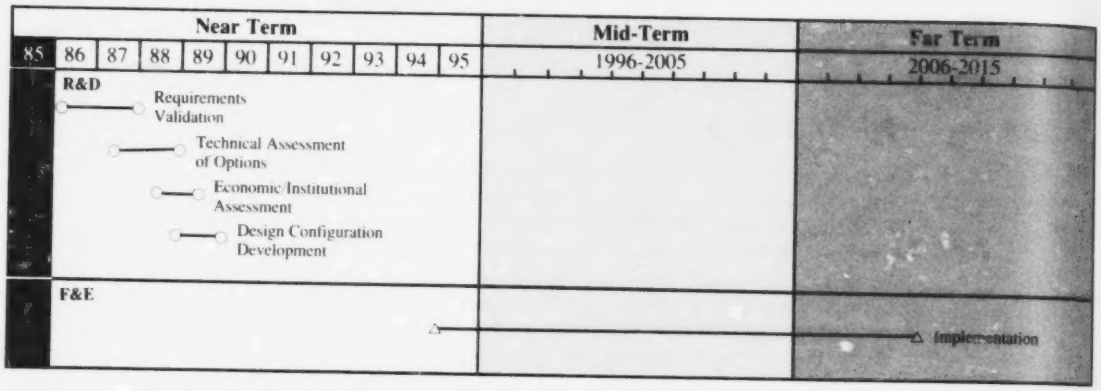
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Studies of CNS System Design Alternatives—the results of these investigations will be used in the satellite-based CNS system design.

Schedule



8.3
Studies of CNS System Design Alternatives

Purpose

To study satellite-based CNS system design alternatives in order to support recommendations for CNS system architecture and design configuration.

Category

E—New Initiatives

Approach

The Satellite-Based CNS System Design Configuration project will develop a system framework for the application of satellite-based CNS systems. Independent assessments will be made of candidate CNS techniques and emerging technologies that have potential for use in the FAA's overall CNS system design and implementation strategy. Assessments will include detailed analyses of the technical and economic characteristics, risk factors, transition strategies, and availability (near, mid-, or far term) of each technique. These assessments may include laboratory simulations and operational testing of prototype equipment to establish the feasibility of the techniques. The design study will include a description of the way the satellite technology is integrated with ground-based services. Guidelines, procedures, and specifications will be prepared for the ground-based equipment and avionics associated with recommended techniques.

In the near term, studies will be made of the capabilities of candidate satellite-based techniques in the following areas of application:

- Communications

  Interfacility communications (inside and outside of CONUS)

  Oceanic/remote area/low-altitude satellite-supported air-ground communications

  Domestic air-ground integrated voice/data satellite communications

- Navigation

  Alternative satellite concepts for civil air navigation techniques

  Satellite navigation techniques for approach and landing

- Surveillance

  Satellite-based automatic dependent surveillance (ADS)— techniques investigated for satellite applications for ADS coverage in oceanic, CONUS, and remote/low-altitude regions

  Satellite-based independent surveillance studies, including investigations of cooperative independent and space-based radar techniques

- Integrated CNS systems

  Functions

  Avionics

Products

- Technical and economic assessment reports of satellite-based techniques for:

  Communications

  Navigation

  Surveillance

  Integrated CNS

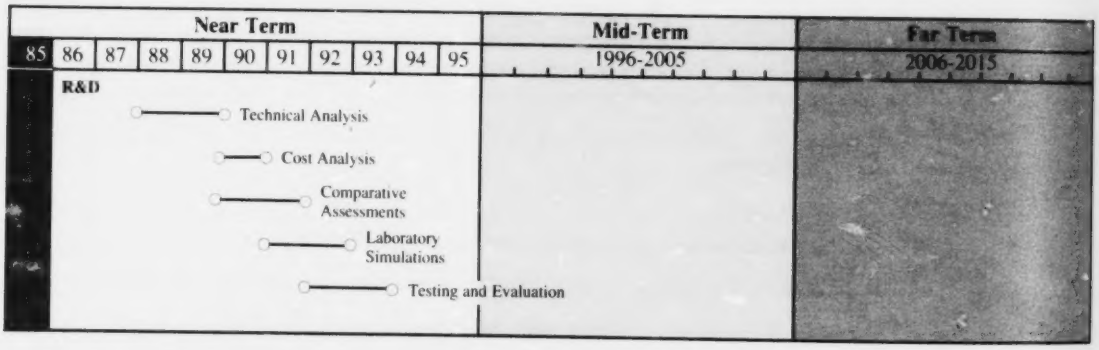
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

None

Schedule



Chapter 9
Avionics

Avionics projects will support the development of airborne communications, navigation, and surveillance components.

The avionics R,E&D projects are limited to the development of airborne communications, navigation, and surveillance (CNS) components not associated with FAA ground facilities developments. Avionics activities associated with an FAA-developed ground system, such as the Microwave Landing System (MLS), are the responsibility of that ground facility development program. The FAA's R,E&D efforts in support of flight control system avionics are covered under aircraft safety.

The principal project in the avionics program area is the Traffic Alert and Collision Avoidance System (TCAS). TCAS is intended to provide a ground-independent airborne collision avoidance capability to reduce the risk of midair collision.

The avionics area also includes a certification R,E&D project airwothiness criteria and technical guidance materials in support of aviation community avionics technology developments.

Another important project is the investigation of onboard instruments for achieving hazardous wind shear detection. Airborne wind shear detection is intended to provide the pilot with look-ahead techniques for early warning.

Avionics Project Summary

Area	Project Number	Project Name
Collision Avoidance	9.1	Traffic Alert and Collision Avoidance System
Certification	9.2	Avionics Certification R,E&D
Data Collection	9.3	Airborne Wind Shear Detection

9.1
Traffic Alert and Collision Avoidance System

Purpose

To develop and prove techniques for providing a viable ground-independent airborne collision avoidance capability, and to provide the aviation community with the standards and certification guidance materials required to support implementation of this capability.

Category

B/C—Direct Support to the NAS Plan with Enhancements

Approach

To support the NAS Plan goal of independent ATC backup, the TCAS concept comprises three basic system components. TCAS I is a relatively simple proximity warning system with the ability to warn flight crews that other aircraft are in the near vicinity. The warning may consist of a simple aural or visual alert, or it may provide a comprehensive traffic advisory announcing the range, altitude, and bearing of the traffic involved. TCAS II provides traffic advisories, and also resolution advisories that recommend collision avoidance maneuvers for purposes of ensuring separation from aircraft on collision or near-collision courses. The resolution advisories that TCAS II displays to flight crews are limited to the vertical plane (e.g., CLIMB, DO NOT DESCEND). The resolution advisories provided by TCAS III will be capable of recommending maneuvers in both the vertical and horizontal planes (e.g., TURN LEFT AND CLIMB, TURN RIGHT).

The development of TCAS techniques is divided into two principal areas: surveillance techniques whereby TCAS can accurately locate aircraft in the local airspace; and computer algorithms that can effectively distinguish between aircraft on near-collision courses and those that are adequately separated, as well as generate resolution advisories for aircraft on near-collision courses so that safe separation is achieved. Surveillance techniques are developed using engineering analysis and simulation, followed by in-flight measurements for verification. The computer algorithms developed are tested using simulations of various near-collision encounters and analysis of algorithm performance in normal traffic environments.

As techniques mature, full-scale engineering model units are fabricated and flight tested at the FAA Technical Center. When engineering model work has been successfully completed, units are fabricated and evaluated on in-service aircraft. The installation of TCAS units on in-service aircraft naturally requires the development of airworthiness criteria for such installations, as well as certification guidance for meeting these criteria. In addition, flight operations procedures must be developed for the associated operational use of the TCAS equipment. The development of airworthiness criteria generally begins with the convening of a special committee of the Radio Technical Commission for Aeronautics (RTCA). This committee provides Minimum Operational Performance Standards (MOPS) that describe the functions and levels of performance required of TCAS equipment, and that incorporate the basic surveillance and computer algorithm requirements contained in TCAS National Standards published by the FAA.

The development of TCAS II is essentially completed. Program activities are limited to two in-service evaluations. One advanced engineering model unit will be installed on a Piedmont B-727 aircraft for an 8-month evaluation. Following this activity, under the Limited Installation Program (LIP), seven production prototype units will be installed on in-service air carrier aircraft for an extended airline community evaluation of the system.

Products

- TCAS I

  MOPS, adopted by RTCA

  Report on rotorcraft application

- TCAS II

  Piedmont Phase II evaluation report

  Certification guidance for LIP

  LIP evaluation reports

- TCAS III

  Draft National Standard

  Report on engineering model flight tests

  MOPS, adopted by RTCA

  Final National Standard

Recent Accomplishments

- TCAS I—functional guidelines adopted by RTCA.
- TCAS II

  MOPS, adopted by RTCA.

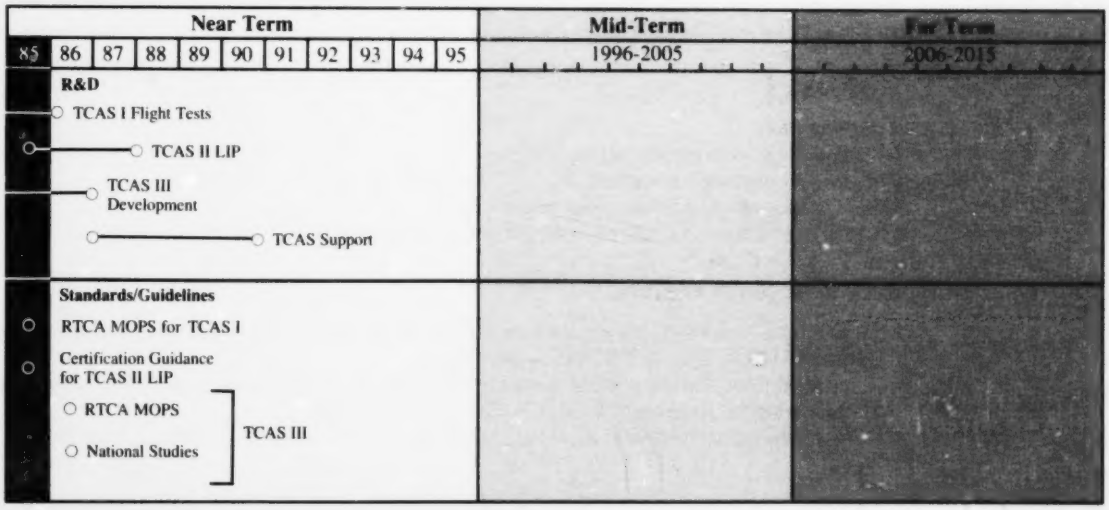
  Final National Standard published.

- TCAS III—engineering model delivered to the FAA Technical Center for flight testing.

Related Projects/Activities

- Avionics Certification R,E&D—supports certification of TCAS equipment.

Schedule



9.2
Avionics Certification R,E&D

Purpose

To support the implementation of new CNS avionics technology through the development of airworthiness criteria and associated technical guidance materials, in parallel with community technology advances.

Category

D—Sustaining R,E&D Activities

Approach

Airworthiness criteria and technical guidance materials, ranging from handbooks of test methods and procedures to proposed advisory circulars on means for demonstrating airworthiness, will be developed through analyses, simulations, bench testing, environmental testing, and flight testing. This effort will include certification criteria and technical guidance for avionics interfaced with ground interactive software associated with such functions as Automated En Route ATC (AERA) 3 in the Advanced Automation System (AAS).

The materials developed will focus on new technologies emerging for application to CNS avionics for civil aviation. In particular, improved techniques for the design, coding, documentation, verification, and validation of avionics software will be developed. In addition, consideration will be given to streamlined environmental test requirements for digital avionics; these requirements will be based on sensing the outputs of the avionics computer's performance monitor during such tests. As flight operations become increasingly dependent upon the reliable performance of aircraft avionics, improved methodologies are warranted for demonstrating that avionics designs provide integrity consistent with the criticality of the functions performed.

It is anticipated that many of the results of this R,E&D activity will be promulgated through MOPS developed by government/industry representatives meeting in special committees of the RTCA. Other results will be distributed independently by the FAA as technical information and community guidance. The initial products for the activity will be defined in the project plan.

Products

- Project Plan
- Updated and new airworthiness criteria
- Technical guidance materials
- Handbooks of test methods and procedures
- Certification data and information for safety compliance

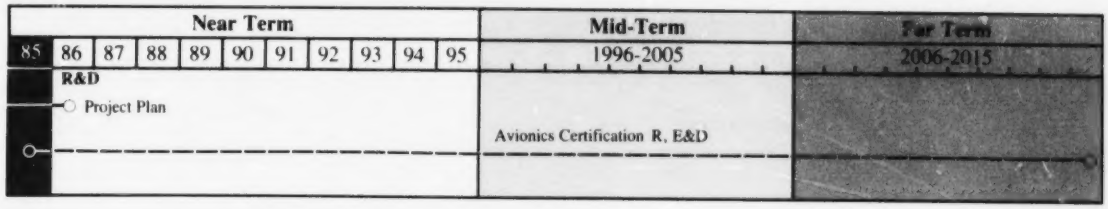
Recent Accomplishments

- Handbook—Volume I, "Validation of Digital Systems in Avionics and Flight Control Applications," July 1983 (DOT/FAA/CT-82/115)—published.
- Combined FAA/Industry Workshops for "Software Considerations in Airborne Systems and Equipment Certification" (Document No. RTCA/DO-178) conducted.
- "Digital Systems Technical Analysis," October 1982 (DOT/FAA/CT-82/129) published.

Related Projects/Activities

- Traffic Alert and Collision Avoidance System—airworthiness criteria and associated technical guidance materials for TCAS will be developed as units are developed for aircraft installation.

Schedule



9.3
Airborne Wind Shear Detection

Purpose

To achieve hazardous wind shear detection and evaluation by use of onboard instruments that will enable the pilot to take immediate appropriate action.

Category

C—NAS Enhancement

Approach

This project will include the development of experimental airborne wind shear sensors based on new technologies, such as Doppler radar or Light Detection and Ranging (LIDAR). Tests will be performed to measure sensor performance in aircraft during periods of thunderstorm microburst activity, frontal passage, or inversion conditions; if these tests are successful, the test data will be analyzed to determine system specifications. Prototype airborne wind shear sensors will be procured, and airborne tests conducted to determine their performance. Standards and a specification for airborne wind shear detectors will be developed as will operational procedures for the use of wind shear avionics to detect and avoid hazards.

Products

- Experimental sensor package design
- Analysis of airborne test data
- Prototype specification
- Prototype test analysis
- Airborne wind shear system specification and standards

Recent Accomplishments

Evaluation completed of the following airborne wind shear displays in ground-based simulators, particularly the Flight Simulator for Advanced Aircraft at the NASA-Ames Research Center:

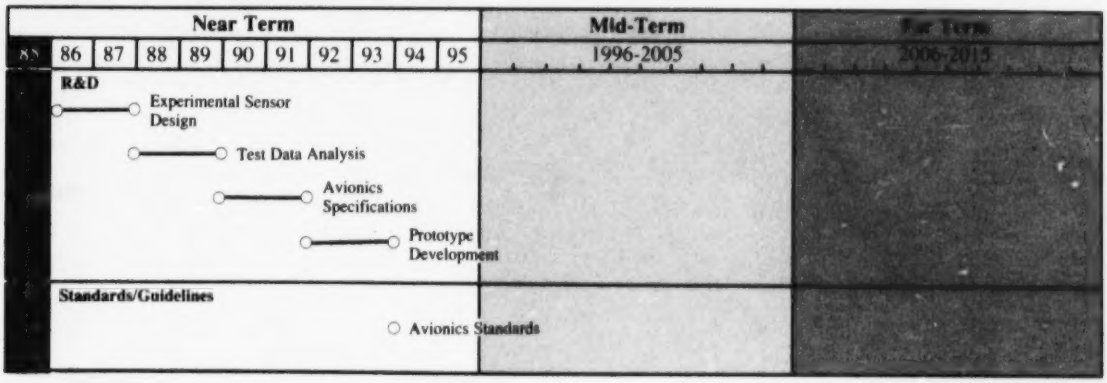
- Air Speed/Ground Speed display
- Safe Flight Wind Shear Monitoring System
- Advanced Vertical Speed Indicator of SFENA (France)
- An Acceleration Margin Display

First three of the above were installed on the FAA Technical Center B-727 aircraft for in-flight evaluation.

Related Projects/Activities

- Airborne Doppler Radar Wind Shear Detection—investigation of the use of airborne Doppler weather radar to detect wind shear

Schedule



Chapter 10
Airports

Airports projects will support the development of standards and guidelines for the design, construction, operation, and maintenance of airports.

The objective of this activity is to support the FAA's responsibility to provide standards and guidelines for the design, construction, operation, and maintenance of airports. These standards and guidelines pertain principally to the airport surface and encompass pavement construction; runway, runway exit, off-runway heliport, taxiway, apron, and gate configurations; firefighting and rescue methods; snow and ice control equipment and methods; airport surface lighting and visual guidance aids; bird and wildlife control; and runway surface contamination detection and removal.

The airport R,E&D activity must anticipate future airport requirements arising from increased demand and new aircraft types entering the civil aviation fleet. Aeronautical technology is expected to make major advances in the coming decades. Technology forecasts by the National Aeronautics and Space Administration (NASA), the National Research Council, joint government/industry task forces, and aviation industry organizations have concluded that the types of aircraft in use today may be technologically superseded by the end of this century. Advanced-configuration subsonic and supersonic aircraft for passenger and freight applications, short take-off and landing (STOL) aircraft, vertical take-off and landing (VTOL) aircraft, advanced general aviation (GA) aircraft, rotorcraft, and tiltrotor aircraft will be operating in the early part of the next century. The specific aircraft types expected to be operating in the future are as follows:

- Near Term (1986–1995)

  Present types of aircraft and their derivatives

  Rotorcraft, including tiltrotor aircraft

  STOL aircraft

  Improved turbine-engine GA aircraft

- Mid-Term (1996–2005)

  Large subsonic passenger aircraft for 600 or more passengers

  STOL and VTOL aircraft

  Large transport/cargo rotorcraft

  Supersonic transports

  Improved GA aircraft

- Far Term (2006–2015)

  New generation of large subsonic passenger aircraft

  Advanced-configuration subsonic and supersonic aircraft for passenger and freight applications

  STOL and VTOL aircraft, and high-speed rotorcraft

  Transatmospheric aircraft

  New-generation GA aircraft

  Long-haul airlifters

  Pilotless aircraft

Some aircraft, such as the large subsonic aircraft and long-haul airlifters, will be bigger and heavier than those currently in use. The operation of these aircraft, although limited to a small number of airports, will require extensive modifications to airport standards to include provisions for wider runways and taxiways, enlarged aprons, and suitably redesigned gates. The strength and durability of the pavement will have to be improved to accommodate landing gears with more wheels, as well as tire pressures and loads higher than those currently encountered.

Tiltrotor and VTOL aircraft will require improved pavement materials with higher resistance to heat and blast. The use of heavier aircraft on rooftops and in urban areas will require a better understanding of the impact of downwash. New aircraft will also introduce new fuels and materials, while crash fire rescue systems will

require new techniques for effectively extinguishing fires involving these aircraft. In addition, new GA aircraft types imply a need to revise GA airport standards.

In the near term, five new primary airports are planned at Atlanta, Denver, Los Angeles, San Diego, and Austin, and perhaps 75 smaller commercial and reliever airports will be constructed. Urban Instrument Flight Rules (IFR) heliport networks will also be established in 15 metropolitan areas. In later years, the number of such heliport networks may double, and a few (4 or 5) very large airports may also be constructed offshore or in the desert to accommodate large subsonic, supersonic, and even transatmospheric transports. However, the majority of the anticipated increase in demand for airport capacity must be accommodated through the expansion and better utilization of existing airports. As a result, it will be necessary to construct additional runways (for example, short runways to accommodate commuter aircraft and rotorcraft landing areas) at existing airports. This will provide additional fixed-wing capacity at those airports now being used by helicopters merely for lack of a more appropriate landing area. Further, the need to integrate the operation of diverse vehicle types and improve the safety of ground operations in conditions of reduced visibility will require improved lighting and visual guidance systems. In addition, high priority is assigned to the development of new techniques for detecting and removing runway contamination, such as ice, snow, slush, and rubber deposits, to improve the safety of all-weather operations.

Airports Project Summary

Area	Project Number	Project Name
Construction	10.1	Pavement Strength, Durability, and Repair
Design	10.2	Airport Design and Configuration
Operation	10.3	All-Weather Taxiway Guidance
Design/Operation	10.4	Airport Safety

10.1
Pavement Strength, Durability, and Repair

Purpose

To develop economical airport pavement designs and design guidelines that will provide increased strength and durability, and reduced requirements for repair.

Category

D—Sustaining R,E&D Activities

Approach

This project will develop new cost-effective techniques and methods for enhancing the strength and durability of geotechnical materials suitable for use as airport pavement components. These components must be sufficiently strong to sustain repeated wheel loading, insensitive to changes in temperature and moisture, and free from frost damage and thaw weakening. Currently, specific additives, such as petroleum products, coal tar, portland cement, lime, fly-ash, granulated rubber from old tires, and sulphur, are being used as stabilizers in geotechnical materials. Certain polymers and resins have also been used on an experimental basis on a limited scale. New polymer binders will be evaluated for their ability to provide even greater strength and durability to pavement components. These binders must be cost-effective when produced in quantity, environmentally acceptable for use in construction, and energy-efficient in production and use. In the use of these additives, mix designs should be easily formulated, and the mixed materials should be easy to handle, cure quickly, and be ready for aircraft traffic in a short period of time. Guidelines will also be developed for storing, hauling, mixing, placing, and compacting these new materials. Possible chemical reactions caused by additives will be investigated, and laboratory samples will be fabricated and tested for their physical properties and durability under various climatic conditions. Limited field testing will also be conducted. For promising materials, full-scale test sections will be constructed, instrumented, and tested under normal operations at airports. This project will also develop heat- and blast-resistant pavement materials for VTOL and tiltrotor aircraft.

In parallel with the development of better pavement materials, improved analytical techniques for pavement design and evaluation will be formulated. These techniques will provide an accurate assessment of pavement response to different aircraft wheel loadings, and model the effects of variations in temperature and moisture. Design methods for pavements in cold regions will be developed that will minimize the effects of frost heave and thaw weakening. Pavement designs based on these new analytical techniques will be compared to the conventional designs, and the most promising technique will be used to design the test sections discussed above.

In addition to improving current methods of nondestructive structural testing, evaluation, and rehabilitation, this project will develop remote sensing techniques for inspecting pavement and detecting delaminated areas, subsurface voids, sinkholes, cracks, layer separations, and density and moisture variations. Ground-penetrating radars, infrared imagery, ultrasonics, resistivity testing, and microseismic techniques will all be evaluated for remote sensing applications. Further, new methods will be developed for obtaining an accurate and reliable estimate of the remaining life of pavements.

Pavements require periodic repair to maintain an acceptable level of performance. Repair procedures will be developed for the new pavement materials, and for pavements for cold regions. The adhesion of repair materials to existing pavements will be improved, and faster-curing repair materials will be developed to provide longer-lasting repair. Improved crack and joint repair, surface and subsurface drainage, slab replacement, crack retardation, and under-sealing materials will also be developed. The use of improved pavement coatings, sealants, and man-made fabrics in pavement repair will be explored. A pavement management system will be developed to provide an efficient and economical program of pavement maintenance and rehabilitation.

Products

- Technical reports and procedure manuals
- Computer programs and users' guides
- Test methods and non destructive testing (NDT) equipment
- Guidelines and criteria for pavement design, construction, and maintenance

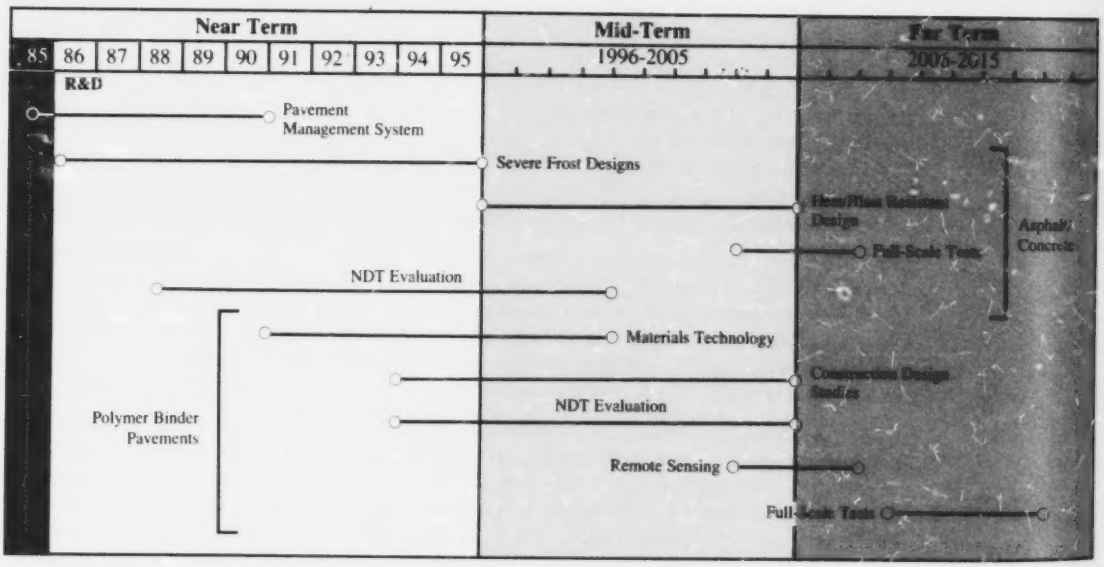
Recent Accomplishments

- Report on longitudinal joint systems performance at Chicago O'Hare published.
- Report on use of confined base course systems in utility airport pavements published.
- Report on airport pavement evaluation using NDT and overlay design published.
- Report on pavement management for airports published.
- Report on evaluation of laser profile and deflection measuring system published.
- Report on evaluation of FAA design procedure for pavements with high traffic volumes published.

Related Projects/Activities

None

Schedule



10.2
Airport Design and Configuration

Purpose

To develop improved airport designs and configurations that will provide greater airport capacity, as well as increased safety and efficiency of ground movement for current and future aircraft.

Category

D—Sustaining R,E&D Activities

Approach

This project will enhance existing analytical and simulation models for evaluating alternative airport configurations, and develop algorithms for optimum location and design of high-speed runway exits for various mixes of aircraft. These algorithms will be tested in simulators for pilot acceptability. A test exit will be installed and evaluated under nominal operating conditions; a performance-monitoring system that will inform pilots if the exit can be safely and comfortably executed will be developed. Guidelines, design criteria, and analytical tools will also be prepared in support of airport designs and configurations that will accommodate all conventional take-off and landing aircraft, as well as integrated facilities for helicopters, STOL, and VTOL aircraft in the airport complexes (e.g., off-runway areas for rotorcraft arrivals and departures). Further, clearances for new aircraft, direct taxiing to ramp, and new fillet designs, curves, and apron requirements will be investigated toward improved aircraft/airport compatibility. Several specific configurations of runways, taxiways, and aprons will be evaluated as regards distances and times required for ground operations. Facilities for STOL and VTOL aircraft and rotorcraft will then be added to these configurations, and the resulting airport systems will be evaluated for overall operating efficiency.

Products

- Technical reports and advisory circulars
- Computer programs and user manuals
- Design criteria and guidelines for airports and heliports
- Test methods and procedures

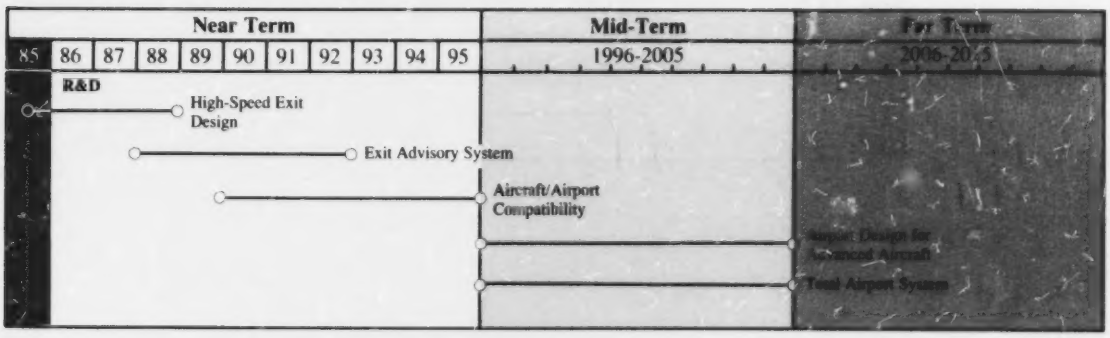
Recent Accomplishments

None

Related Projects/Activities

None

Schedule



10.3
All-Weather Taxiway Guidance

Purpose

To support the ground movement of aircraft and other support vehicles in zero visibility by providing necessary guidance on the airport surface.

Category

D—Sustaining R,E&D Activities

Approach

Alternate system concepts will be developed for guiding the aircraft upon landing, before take-off, and during other ground movements in zero/zero weather conditions. Similar concepts will be developed for providing all necessary ground support services, such as baggage handling, refueling, firefighting, evacuation, and rescue. Laboratory simulations will be used to determine the technical and operational feasibility of proposed concepts. Prototype equipment will be developed for limited operational evaluation of promising concepts. Based on the results of the tests and evaluations, operational guidelines and equipment design specifications will be developed.

Products

- Comparative assessment of alternate concepts
- Report on operational test and evaluation of prototype equipment
- Performance specifications for ground-based and user equipment
- Guidelines for integrating these systems into the NAS

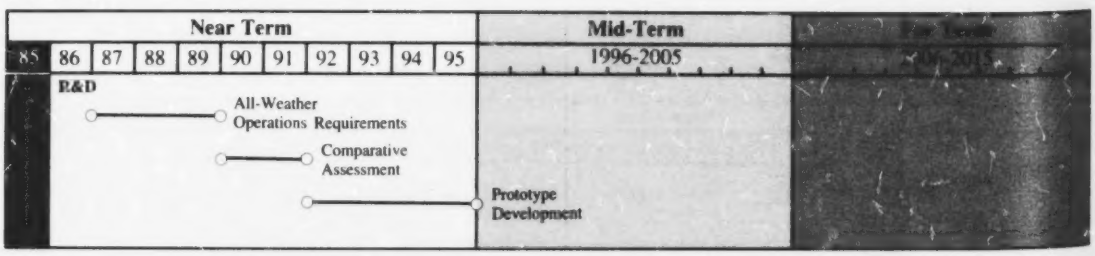
Recent Accomplishments

None

Related Projects/Activities

- Airport Surface Traffic Automation—will define the functional requirements of an operational taxiway guidance system.

Schedule



10.4
Airport Safety

Purpose

To improve the safety of aircraft and support vehicles at airports by providing enhanced visibility; wildlife control; improved crash, fire, and rescue (CFR) and refueling systems; better sensing and removal of snow and ice; and aircraft-arresting systems in overrun areas.

Category

D—Sustaining R,E&D Activities

Approach

Improved lighting and visual aids will be developed for the landing environment down to Category (CAT) IIIC conditions. These aids will include improved visual signs and markings, distance-to-go markers, and other advanced systems for guiding aircraft both ways between apron and runway. Lighting and visual aids unique to heliports and STOL and VTOL aircraft facilities will also be developed. New concepts of lighting and its energy sources, as well as self-contained systems requiring little or no maintenance, will be investigated.

The presence of wildlife, such as birds and ground animals, at airports creates potentially unsafe conditions; such wildlife must be kept away from aircraft. Wildlife and habitat control techniques will be evaluated. These include, among others, the use of scare devices, such as noise, strobe lights, and falcons; the use of chemicals, ultrasound, and microwaves; and the construction of alternate habitats away from airports. The use of air and ground radars for detecting wildlife will be investigated.

A state-of-the-art study and a manual on current firefighting systems will be prepared. Preliminary laboratory tests will be conducted to evaluate aqueous film-forming foam (AFFF), fluoroprotein foam (FPF), protein foam (PF), and compatible dry chemical agents. Full-scale fire tests will be conducted on promising systems. Advanced firefighting agents, equipment, and procedures will be developed to meet the fire-extinguishing requirements of future aircraft using new composite materials. Sensors for detecting fuel leaks from buried tanks, as well as siting and design criteria for safer fuel facilities, will be investigated.

Ground friction devices will be evaluated in aircraft braking tests on dry, wet, snow-covered, and icy pavements. Fundamental studies will be conducted on the effects of tire parameters, pavement characteristics, runway profiles, and drainage on aircraft braking and lateral forces. New sensors for detecting water, slush, snow, and ice on runways, as well as improved methods of removing these substances, will be developed. A method of predicting aircraft braking performance under adverse weather conditions and informing the pilots of potential hazards will also be developed.

The use of gravel, sand, foam, and other soft ground materials will be evaluated for safely arresting aircraft in runway overrun areas, and appropriate design criteria for such arresting systems will be established. Further, a cockpit display of longitudinal acceleration will be developed as an aid during take-off and landing.

Products

- Research reports and design criteria
- Computer programs and users' guide
- Specifications and procedures manuals
- Technical basis for Federal Aviation Regulations (FAR) Part 139 rule making
- Lighting standards for airports and heliports

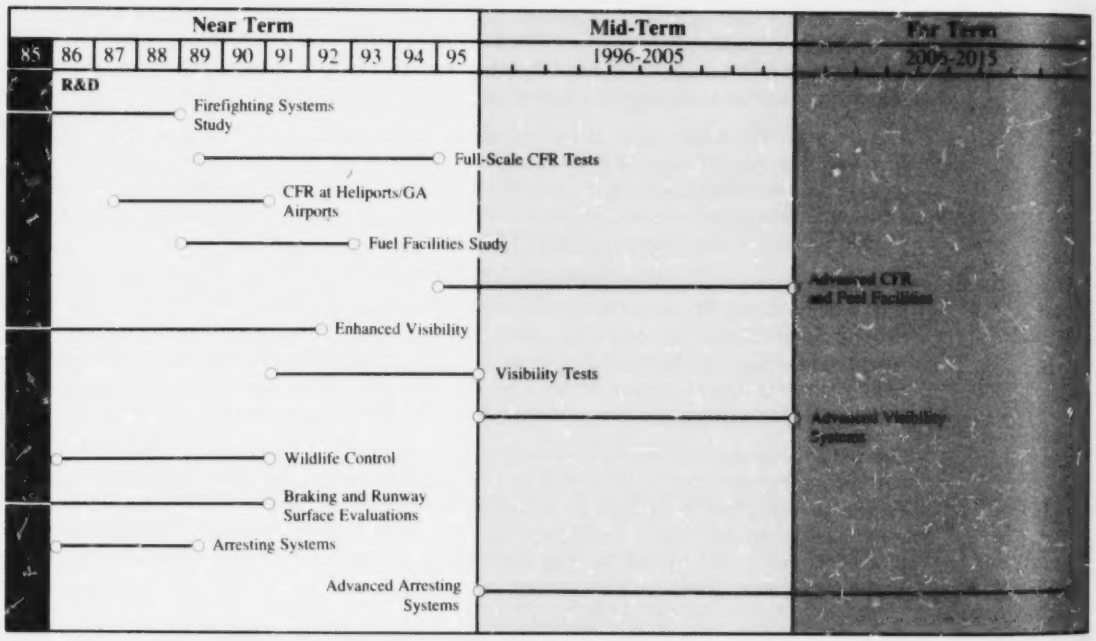
Recent Accomplishments

- In-service evaluation of reflective runway markers and Runway End Identifier Lights (REILs) completed.
- Evaluation of unpaved runway marking/lighting completed.
- Equivalency evaluation of firefighting agents and minimum requirements at U.S. Air Force airfields completed.
- Wet and dry test comparing B-737/Runway Friction Measuring System (RFMS) completed.
- Final report on runway surface treatments grooving published.
- Report on study of improved rubber removal from porous friction course published.

Related Projects/Activities

- Automated Terminal Information Service—This FAA service provides a link to inform pilots of runway friction values, and the type and amount of contaminants.

Schedule



Chapter 11
Aircraft Safety

Aircraft safety projects will maintain and improve aircraft and passenger safety.

The aircraft safety projects described here have a common goal of maintaining and improving aircraft and passenger safety without imposing unnecessary constraints on the aviation industry. They also emphasize near-term activities, such as performing technical and economic evaluations of proposed amendments to regulations, developing certification criteria, and providing advisory circulars related to changing technologies.

The safety projects cover two major areas—airworthiness and crashworthiness. The airworthiness area stresses flight safety, and includes such activities as the establishment of airworthiness criteria for aircraft structures and propulsion systems, the assessment of atmospheric and electrical hazards, the development of icing certification criteria for all categories of aircraft, and the development of guidelines for certification and maintenance of onboard hardware and software. The crashworthiness area stresses passenger and crew safety in post-crash environments, and includes such activities as the development of flammability and toxicity criteria for materials, the detection and control of onboard fires, the evaluation of seat structures and passenger restraint systems under dynamic crash loads, and the continued evaluation of emergency procedures.

In some research areas, such as structures, flight and fire safety, and propulsion, the FAA has unique capabilities and laboratory facilities. In certain areas of fundamental research, however, the projects will closely monitor the development activities of the National Aeronautics and Space Administration (NASA), the U.S. Department of Defense (DOD), and aircraft manufacturers. This coordination will ensure the timely development of appropriate regulations and certification criteria so that new mature technologies can be introduced in civil aviation without undue delays.

This activity will also develop improved methods for assessing the environmental impacts of aircraft; this effort will include an assessment of needs for reducing any adverse impact.

It is widely recognized that major advances can be expected in the future in several areas of aeronautical technology, such as aerodynamics, propulsion, structures, materials, guidance, navigation, and control. The aircraft safety projects will attempt to keep pace with these developments in an effort to better fulfill the agency's safety mission.

These projects mainly address the following four areas:

- Fire Safety
- Crashworthiness and Structural Airworthiness
- Propulsion
- Flight Safety

Fire Safety

Advanced composites will be used increasingly in aircraft construction during the next several decades. Metallic parts that melt when exposed to an intense fire will be replaced by parts made of high-strength, lightweight graphite/epoxy materials that burn when so exposed. The fireworthiness of such structures thus becomes an issue of great concern.

There is also a great potential for disaster on board aircraft with all-electric flight controls when fires are not quickly detected and extinguished or brought under control. Automated detection and suppression techniques will be used more extensively in future aircraft. Improved analytical techniques and validated test procedures will therefore be required so that new standards can be developed for flammability, smoke, and toxicity. Such standards can be developed simultaneously with the introduction of new materials if the manufacturing industry offers adequate cooperation during the development of these materials.

The possibility of post-crash fuel fire will also continue to be an important issue with the development of alternate fuels, such as liquid hydrogen, liquid methane, or other synthetic fuels, for use in aviation. Several factors, such as aircraft fueling, fuel tank containment, vaporization, and dissipation, will have to be investigated to ensure fire safety.

Crashworthiness and Structural Airworthiness

Within the next several decades, advances in structural technology are expected to result in the use of pliable, adaptive, and damage-tolerant structures made of lightweight, high-strength materials. However, structural development is highly dependent on two other technologies—materials and fabrication. The development of metal-covered composites will have a major impact on advanced structural designs. However, the large-scale application of composites will require the development of new, efficient processing and fabrication techniques, as well as quality control and inspection procedures.

Adaptive structures may be used to modify vehicle configuration in flight to achieve optimum performance. This approach may include actively controlled landing gears; optimum blending of wings, fuselage, and engine inlets; and energy-absorbing structures for crash protection and for control of airframe dynamic response. The certification of active landing gears using durable tires will require a comprehensive understanding of their dynamic behavior. This will in turn require the nonlinear simulation of cyclic motions of large amplitudes, as well as the modeling of energy-absorbing structures.

Cruise speeds above Mach 2 will require airframe structures with load-carrying capability at temperatures above 140° C. New powder metallurgy aluminum alloys, such as Ce-Fe-Al, could possibly be used at temperatures up to 250° C. Graphite/polymide composite materials, titanium alloys, and boron/aluminum and graphite/aluminum metal matrix alloys are also being developed for high-temperature applications.

It is anticipated that the aircraft of the next century will have structural configurations different from those of today; structures will also be constructed using very different materials. The aircraft R,E&D program plans to develop crashworthiness and airworthiness criteria, performance standards, and certification guidelines for these evolving materials and structures.

Propulsion

Advances in propulsion technology over the next several decades will involve the application of computational fluid dynamics to design internal flows, the use of smart controls, the application of extreme heat-resistant materials as they are developed, and a better understanding of heat transfer effects in engines. Aircraft equipped with such advanced propulsion systems will fly higher, farther, and faster than current aircraft.

Advances in computational fluid dynamics will permit quantitative tradeoffs between aerodynamic performance, structural characteristics, and weight of propulsion system components. The ability to predict hot-section heat transfer quantitatively will result in more uniform metal temperatures, lower cooling flow rates, and longer equipment life.

The continuing revolution in microelectronics will increase data processing and storage capacity on board aircraft by several orders of magnitude. Advances in this area and in sensor technology will make it possible to incorporate smart controls into engine components, resulting in performance optimization and extended engine life.

In the next few decades, lightweight nonmetallic structures will be used in aircraft engines, and metals will be gradually replaced by ceramics in hot sections. Turbine blade materials will be advanced versions of the present single crystal-type systems, with increased dependence on thermal barrier coatings to reduce cooling requirements. The future development of present superalloys will yield a 50-100° C improvement in metal temperature capability; the use of fiber-reinforced systems could result in an additional improvement of 50-100° C.

Ceramics will be introduced initially in combusters and in turbine vanes, and eventually, solid ceramic parts will be used in engines. Ceramic materials offer a potential improvement of 200-300° C in maximum permissible operating temperature. Composite structures will be an integral part of propulsion system improvements because they are lighter than corresponding metal components. There will be greater use of composites in the near future if higher temperature capability can be achieved. Current composite systems have allowed operation up to 260° C at reduced weight. It is conceivable that polymeric composite materials capable of operating at 540° C will be used in complex engine structures, such as frames, casings, stators, and ducting.

Flight Safety

Although icing protection is important for all aircraft, it is particularly important for helicopters and general aviation (GA) and commuter aircraft, which typically operate for extended periods at low altitudes. Most large aircraft rely on great amounts of engine bleed air for icing protection. However, future advanced turboprops and other engines, with their small cores, may not provide the necessary quantities of bleed air. Also, composite materials, with their lower thermal conductivity, may preclude the use of such systems. Different icing protection based on entirely new concepts will therefore be required for future use.

Advanced ice protection concepts that rely on removing ice (deicing) rather than preventing ice build-up (anti-icing) can offer significant weight and power savings. Some of these advanced concepts include electro-impulse and piezo-electric systems; fluid systems using efficient porous bleed devices; advanced cyclic electro-thermal systems; microwaves to create a liquid boundary at the ice-aircraft interface; and possibly boots for helicopter rotors. Design methodologies will be developed based on improved analyses of these concepts. Since ice will be allowed to build up on both unprotected and protected components before it is removed, advanced analytical methods will be developed for predicting the associated aerodynamic penalties, and for developing aircraft component geometrics for minimum buildup. Emerging fluid dynamics modeling techniques will be used to predict droplet trajectories, impingement regions, ice growths, and the resulting separated flow.

Advances in guidance, navigation, and flight control technology will also have a major impact on future aircraft designs. Improved avionics and the integration of aerodynamic, propulsion, and structural controls will provide improved aircraft performance, new flight capabilities, and increased aerodynamic stability. The benefits of such integrated designs have already been demonstrated. By the year 2000, ultra fault-tolerant, high-integrity flight control systems architecture will be available to support virtually any vehicle configuration. Flight and landing safety can then be maintained in the event of component failures. These systems will be highly reliable, and will have embedded fault reconfiguration capability. New methods of certification for these systems will be developed so they can be verified and validated in a cost-effective manner.

In this regard, effective software management will be vital in the future. Improved software specification and documentation techniques, low-error-rate coding techniques, automated verification and testing, and improved software maintenance methods will be developed to reduce the life-cycle costs of future complex software systems.

Aircraft Safety Project Summary

Area	Project Number	Project Name
Fire Safety	11.1	Aircraft Systems Fire Safety
Crashworthiness and Structural Airworthiness	11.2	Aircraft Crashworthiness
Propulsion	11.3	Propulsion and Fuel Systems
Flight Safety	11.4	Aircraft Icing
Flight Safety	11.5	Airworthiness
Environment	11.6	Environmental Impact Studies
Aircraft Certification	11.7	Regulatory Development Support

11.1
Aircraft Systems Fire Safety

Purpose

To minimize fire-related injuries and increase the survivability of aircraft occupants during in-flight and post-crash fires by developing criteria for interior materials, and by recommending effective aircraft fire management and suppression systems and evacuation aids.

Category

D—Sustaining R,E&D Activities

Approach

Procedures will be developed for the use of aircraft ventilation and environmental control systems for fire control and emergency smoke ventilation. Improved procedures and techniques will be evaluated for their effectiveness in locating and extinguishing post-crash cabin interior fires. In addition, methods will be developed for improving the burn-through resistance of an aircraft fuselage to an external fuel fire in a post-crash environment. Full-scale laboratory tests will be conducted to develop improved fire protection measures against hidden fires in transport aircraft.

The extent of the toxic threat to cabin occupants resulting from aircraft fires will continue to be evaluated to determine the hazard. Further, it will be determined whether the current regulations and fire protection criteria for hydraulic fluids and electrical wiring are adequate. Also, relationships between oxygen systems and fire progression will be identified.

Prototype software and hardware modules for an aircraft fire advisory system will be developed. Such a system would automatically direct the crew on the best course of action during an aircraft fire.

An improved human survival model will be developed for fire and fire products. The fire performance of new composite materials will be evaluated. Further, the state of the art in fire control technology will be examined for its application to GA aircraft and rotorcraft.

Products

- Report on fire toxicology
- Assessment of graphite fibers
- Report on post-crash cabin firefighting
- Full-scale fire tests of graphite panels
- Technical data package on hidden fires
- Report on onboard fire management system
- Evaluation of lavatory fire protection
- Improved human survival model
- Small-scale tests on composite structural materials
- Improved requirements for oxygen systems
- Procedures for in-flight smoke venting
- Improved requirements for hydraulic fluids
- Evaluation of fire safety of advanced fuels

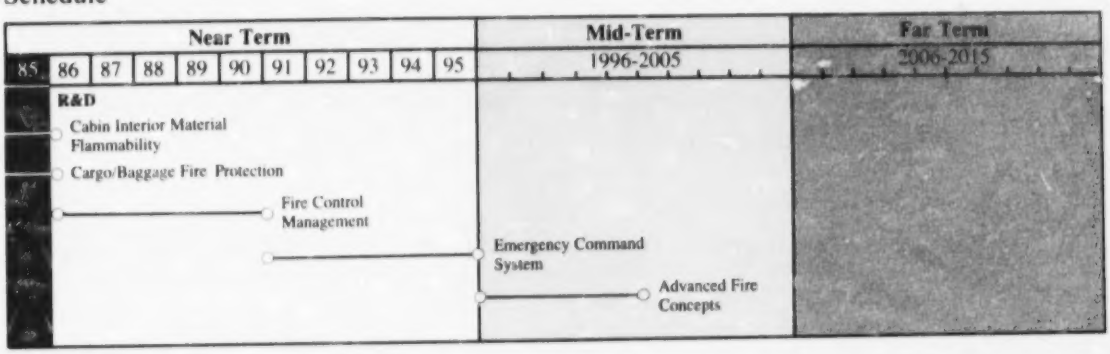
Recent Accomplishments

- Final rule on flammability requirements for aircraft seat cushions published.
- Final rule on floor proximity emergency escape path marking published.
- Notice of Proposed Rule Making (NPRM) on fire protection requirements for cargo or baggage compartments published.
- NPRM on airplane cabin fire protection (fire extinguishers and smoke detectors published.
- NPRM on improved flammability criteria for materials used in interiors of airplanes published.

Related Projects/Activities

None

Schedule



11.2
Aircraft Crashworthiness

Purpose

To establish an appropriate technical data base for preparing crashworthiness criteria, and to develop test procedures for demonstrating compliance with such criteria.

Category

D—Sustaining R,E&D Activities

Approach

This project concentrates on generating the technical data needed to publish advisory circulars and field guidance for the FAA engineers to use in effectively evaluating advanced materials, structures, and designs for type certification and maintenance requirements.

The impact characteristics and crash resistance of metal and composite structures will be examined as a first step in understanding the behavior of fuselage, of seat structures with passenger restraint systems, and of occupants under dynamic crash loads. Large composite structures will also be evaluated as part of this effort. Analytical techniques will be developed for evaluating multiple seating of occupants in metal and composite seat structures. Seat and airframe models will be integrated using established crash scenarios. Improved emergency egress design concepts will also be evaluated.

A generic analytical model of the crashworthiness of both rotorcraft and commuter aircraft with high and low wings will be calibrated. This model will be modified later as new types of aircraft are introduced in service. Further, new concepts will be identified for enhancing the ability of aircraft fuel systems to resist rupture in a crash environment.

Also, under this project, updated criteria for the certification and maintenance of radial and other tires, wheels, brakes, and landing gear systems will be developed.

Products

- Support data for advisory circulars (ACs), NPRMs, and final rules concerning updated certification criteria for aircraft passenger seats
- Technical data package for design criteria for transport crash-resistant fuel system
- Report on structural response of composite aircraft
- Data package on crash scenario analysis of rotorcraft, GA, and commuter models
- Data to support the certification criteria for radial tires

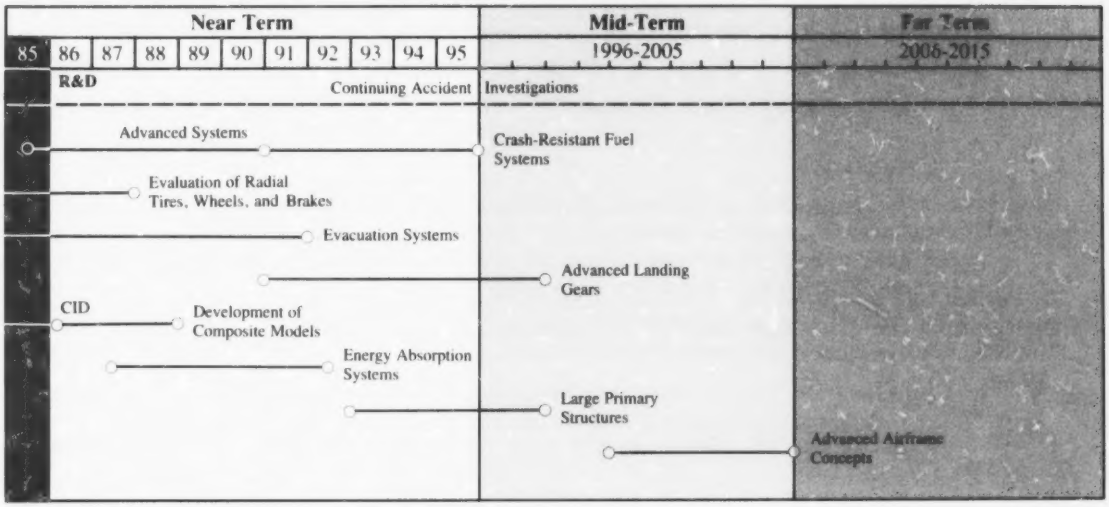
Recent Accomplishments

- Survival controlled impact demonstration (CID) of Boeing 720 aircraft equipped with instrumented seats and dummies completed.
- Data developed to verify analytical models that predict aircraft, seat, and human response in a crash environment.
- Report on transport crash environment published.
- Report on rotorcraft crash environment published.

Related Projects/Activities

- Protection and Survival—Human tolerance specification study and seat tests conducted under this project will supplement the data base supporting regulatory changes with regard to seat strength.

Schedule



11.3
Propulsion and Fuel Systems

Purpose

To develop airworthiness criteria and related technical materials that will ensure the safety and reliability of power plants on commercial and GA aircraft.

Category

D—Sustaining R,E&D Activities

Approach

This project involves the development of criteria, guidelines, and data to support improvements in the certification requirements for turbojets and piston engines. In particular, revised criteria, standards, and testing guidelines will be developed relating to icing certification, and to the ingestion of birds, excessive rain, and runway water by transport turbojet engines.

The effects of uncontained turbine engine failures will be determined. This effort will include identifying ways to minimize material defects that cause such failures.

Current fire protection requirements and associated power plant guidelines will be evaluated with reference to advanced engine materials and alternate fuels, such as autogas (gasoline used for automobiles), alcohol, and methanol. Nacelle cooling problems in higher-performance engines will also be examined.

Products

- Report on autogas detonation limits for high-compression engines
- Report on Nacelle cooling effects
- Report on water measurement techniques for turbine engines

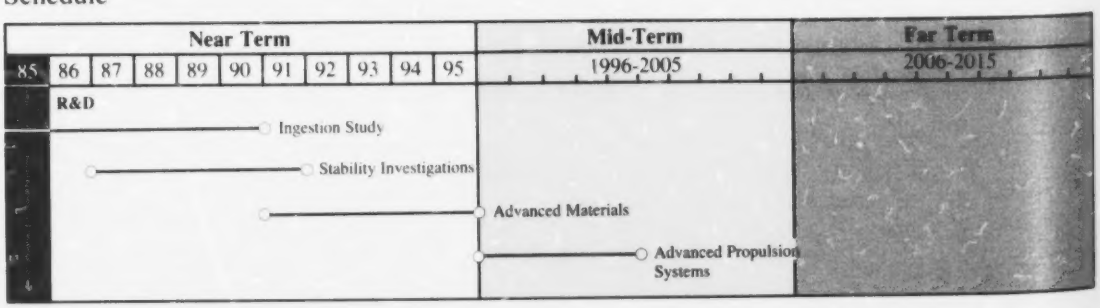
Recent Accomplishments

- Final report on effects of bird weight versus bird density completed.
- Controlled impact demonstration (CID) conducted.
- Project on the use of autogas in aircraft piston engines completed.

Related Projects/Activities

None

Schedule



11.4
Aircraft Icing

Purpose

To obtain the technical data necessary to develop certification standards and flight procedures for icing conditions for all categories of aircraft.

Category

D—Sustaining R,E&D Activities

Approach

The worldwide atmospheric flight environment will be defined, to include such parameters as supercooled clouds, snow, ice crystals, freezing precipitation, and mixed conditions from ground level through all flight levels.

In cooperation with DOD/NASA, natural icing conditions will be simulated, and improved certification guidance for anti-icing/deicing equipment will be developed. Calibration standards for icing instrumentation will also be developed. Further, alternate ice protection technologies for minimizing ice accumulation on an aircraft on the ground will be evaluated.

Products

- Atmospheric characterization reports (CONUS)
- Aircraft icing handbook
- Correlation of icing simulation facilities report
- Atmospheric characterization reports (worldwide)
- Report on simulation in icing certification
- Investigation of engine icing

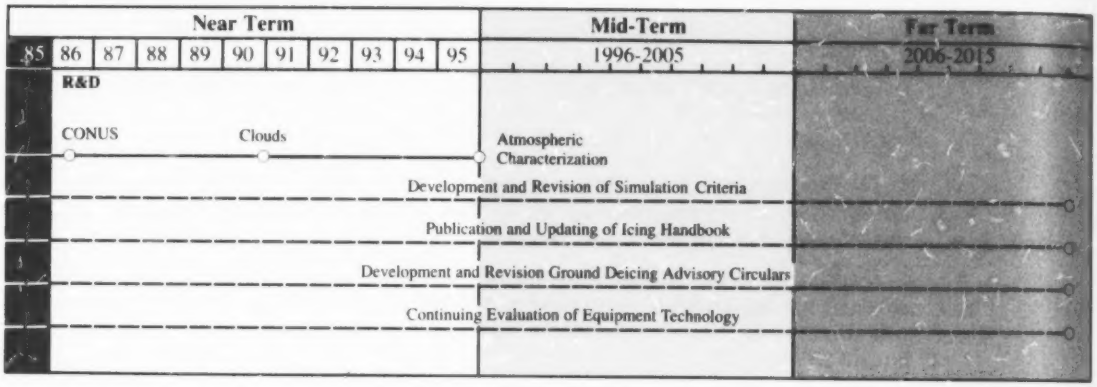
Recent Accomplishments

- Report on snow simulation study published.
- Aircraft ground deicing report published.
- Report and user's manual on atmospheric characterization of supercooled clouds below 10,000 ft above ground level (AGL) published.

Related Projects/Activities

- National Icing Program—This plan, being developed jointly by the FAA, DOD, NASA, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Office of the Federal Coordinator for Meteorology (OFCM), will identify national needs in the area of icing research.

Schedule



11.5
Airworthiness

Purpose

To provide a technical data base for assessing the airworthiness of advanced fixed- and rotary-wing aircraft in relation to such hazards as aircraft lightning strikes and electromagnetic interference (EMI); to provide aircraft occupants with an equivalent or increased level of survivability when advanced airworthiness concepts are introduced and approved for service; and to provide guidance on software configuration control concepts used in flight control.

Category

D—Sustaining R,E&D Activities

Approach

A technical data base will be developed for specific technical areas, partly in cooperation with NASA, DOD, and others. This effort will include analyses, ground testing, flight testing, and simulations designed to establish, validate, and update agency criteria.

The adverse effects of lightning and electromagnetic interference on digital systems and advanced flight controls on board an aircraft will be assessed from the point of view of flight safety. Further, configuration control concepts will be developed for validating digital software and flight control hardware. Special requirements for specific rotorcraft flying qualities, such as low-speed handling and single-pilot Instrument Flight Rules (IFR) guidelines, will also be investigated.

The airworthiness of rotorcraft will also be investigated in an effort to enhance their capabilities under all environmental conditions. Certification guidelines for microelectronic flight and engine control systems will also be developed.

Products

- Report on airborne lightning threat
- Report on lightning simulation techniques
- Handbook of Aircraft Lighting Protection
- Study on effects of aircraft-generated electromagnetic interference (EMI) on onboard digital systems
- Assessment of reliability of onboard hardware and software

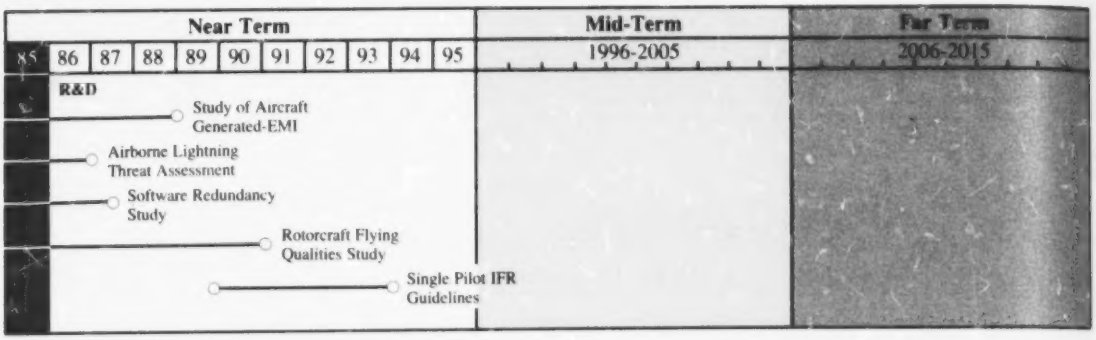
Recent Accomplishments

- Annual conference on Lightning and Static Electricity established.
- Digital System Validation Handbook published.
- Work completed in support of an advisory circular and user's manual—"Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning."

Related Projects/Activities

None

Schedule



11.6
Environmental Impact Studies

Purpose

To develop accurate means for assessing the environmental impacts of aircraft operations, and to reduce these impacts through improved technology and revised community standards. The objective is to minimize environmental constraints on the growth of the national air transportation system, especially airports, by developing methods, technology, and expertise needed to mitigate or control the environmental impacts of such growth.

Category

D—Sustaining R,E&D Activities

Approach

Aircraft noise in the vicinity of airports has been reduced over the years with the use of improved hardware designs, revised certification standards, and effective noise-abating operating procedures. Emission controls have also been placed on aircraft engines. These efforts will be continued so that the aviation community and the general public will have the most cost-effective NAS with the fewest negative environmental and health effects.

A data base on civil helicopter noise will be developed as a basis for reasonable noise standards for civil helicopters. Noise compatibility criteria for heliports will also be developed.

Methods for accurately measuring and quantifying the reaction of airport neighbors to aviation noise will be evaluated. Noise compatibility programs of airport sponsors will be reviewed, and guidelines for appropriate land use and building construction will be developed. Noise characteristics and sonic booms of current and projected aircraft will be defined. Better methods will be developed for predicting noise generated by various systems on board an aircraft. Different noise control technologies will be examined from technical and economic perspectives.

The chemical and physical processes by which aircraft engine emissions degrade air quality around airports and in the upper atmosphere will be examined. Special Federal Aviation Regulation (SFAR) 27 will be revised to reflect current Environmental Protection Agency (EPA) standards on engine emissions. Finally, a computerized model for the assessment of aircraft/airport emissions will be developed jointly with the U.S. Air Force for use at both civil and military airports.

Products

- Report on the prediction and assessment of impacts of aircraft and helicopter noise
- Improved compatibility criteria for land use near noise-impacted airports
- Simpler noise certification procedures for aircraft

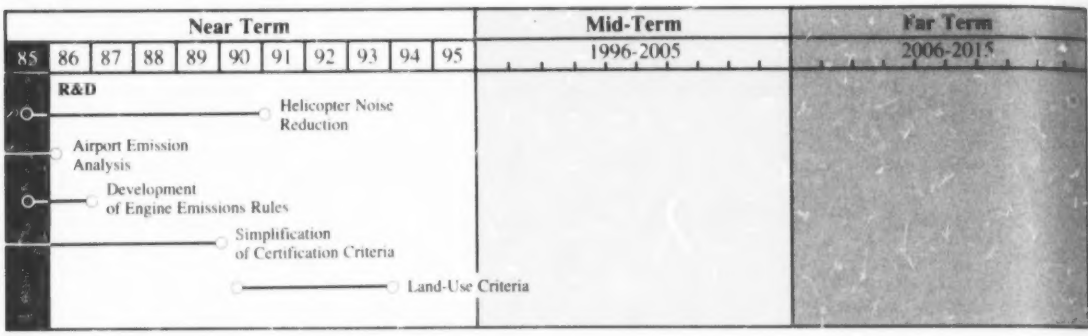
Recent Accomplishments

- Helicopter Noise Certification Rule issued.
- NPRM on Airport Noise Compatibility issued.
- Environmental impact analysis of aircraft noise completed.
- Improved aircraft engine emission certification procedures developed.
- Model for analysis of pollution dispersion around airports developed.

Related Projects/Activities

None

Schedule



11.7
Regulatory Development Support

Purpose

To develop technical data, guidelines, and test equipment techniques and procedures in support of ongoing regulatory development, aircraft certification, and safety-related activities in other government agencies.

Category

D—Sustaining R,E&D Activities

Approach

The potential impact of future technical development on aircraft and passenger safety and on the agency's regulatory process will be assessed through technical studies, laboratory tests, and simulations. Vital data will be generated in support of the updating of standards, criteria, advisory circulars, and other agency documents.

Products

- Technical data packages
- Advisory circulars
- Staff studies
- Impact assessments

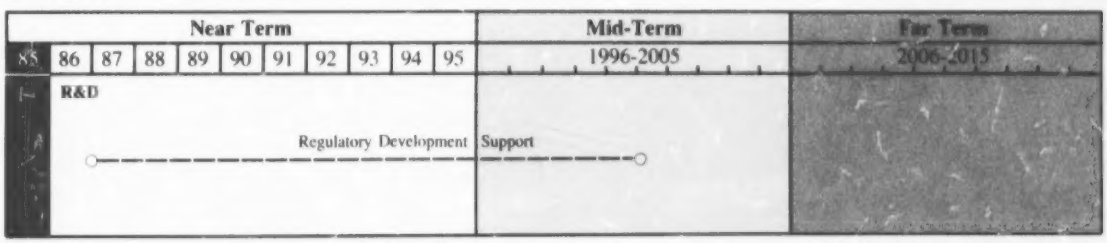
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

None

Schedule



Chapter 12
Aviation Medicine

Aviation medicine projects will promote the safety of civil aviation, as well as the health, safety, and efficiency of FAA employees.

The discipline of aviation medicine covers a broad spectrum of work related to medical, behavioral, and human factors technology. The FAA's work in this area is aimed at promoting not only the safety of civil aviation, but also the health, safety, and efficiency of agency employees. Different divisions within the agency, such as Air Traffic, Personnel and Training, Flight Operations, Airworthiness, the Technical Center, and others, request specific aeromedical research projects addressing their human-oriented problems. Most of these research efforts are conducted in-house at the Civil Aeromedical Institute (CAMI) in Oklahoma City; they are supplemented by the efforts of the Office of Aviation Medicine (OAM) and its contractors.

OAM research facilities include the Boeing 727 simulator, a hypobaric test chamber, protective breathing equipment and a water survival test laboratory, a dynamic impact test track, and computerized radar simulation equipment for the assessment of ATC procedures. Also available are modern laboratories for toxicological research, for accident investigation, and for studies of human behavior and performance, with particular emphasis on ATC problems. These laboratories are used to examine a variety of problems, including the development of impact test criteria for air carrier passenger seats, studies of stress fatigue for Air Traffic Control Specialists (ATCSs), the relationships of various indices of airman performance to age, and the development of new ATCS selection/training methods.

Over the next several decades, one can expect that advances in the technology of airspace management will result in a smaller, more efficient, and specialized agency workforce. Changing characteristics of the airman population and the introduction of new carriers, equipment, and procedures will all require continuing OAM research efforts to ensure the highest level of civil aviation safety. Of particular concern will be transition to the changing roles of pilots and controllers as increasing levels of automation are introduced.

The major objectives of the aviation medicine research projects are as follows:

- To develop comprehensive, statistical, and conceptual databased systems for optimizing the productivity and performance of the agency operational workforce at a minimum cost to the public.
- To develop procedures and analytical techniques for reducing human errors in airspace management.
- To develop appropriate medical standards for airmen and agency operational personnel, and maintain a high level of occupational health and safety standards in a cost-effective manner.
- To reduce the potential for injury or loss of life following aircraft accidents or incidents.

OAM research projects differ in some respects from projects oriented towards the development of some specific hardware; they support and emphasize the human aspects of other major projects, such as the Advanced Automation System (AAS), the Voice Switching and Control System (VSCS), and Automated En Route ATC (AERA), which must often be modified because of societal changes or because of new data available in such areas as operational errors by pilots or controllers. In an effort to more fully utilize the advances being made in human factors technology and optimize the efficiency and safety of the total system, such projects will continue to be identified and/or modified so that the objectives outlined above can continue to be met or exceeded well into the far term.

Aviation Medicine Project Summary

Area	Project Number	Project Name
Behavioral	12.1	Agency Workforce Optimization
Human Factor	12.2	Human Performance
Safety	12.3	Protection and Survival
Medical	12.4	Aeromedical Program Support

12.1
Agency Workforce Optimization

Purpose

To increase the efficiency and productivity of agency personnel through the application of human factors research, while at the same time maintaining and improving employee attitudes.

Category

D—Sustaining R,E&D Activities

Approach

A personnel tracking system will be developed to monitor variations in personnel performance resulting from the introduction of new equipment, fatigue, illness, use of drugs, and other job stresses. The data base will identify changes as they occur, and describe when and where they occur. It will also relate these changes to resulting new personnel requirements and to old tasks that are eliminated. This data base will also be used to create new tests and procedures for selecting personnel and for measuring performance. In addition, it will identify requirements for new training courses and training equipment. As students are trained, the data base personnel performance will be continually expanded and used for the evaluation of selection procedures and training courses. The data base will be used statistically to define the profile of an individual likely to succee in the training schools, and to evaluate the performance of students and instructors. Customized data bases w also be developed to meet any other specialized requirements that may arise.

Products

- Encyclopedic state-of-the-art report on the selection of air traffic controllers
- Criteria for identifying training and training equipment needs
- Methods for evaluating training programs and methods
- Guidelines for security personnel to follow in observing people at boarding gates to detect potential hijacke and terrorists
- New performance tests, rating methods, and procedures for evaluating air traffic controllers
- Statistical models and methods for combining scores to predict on-the-job performance for comparison wit observed performance

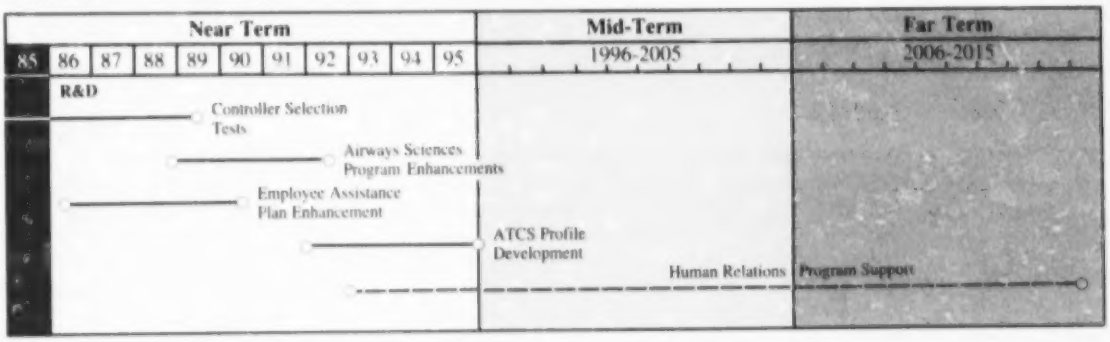
Recent Accomplishments

- New forms of controller aptitude and occupational knowledge tests developed.
- Agency workforce attitude survey completed.
- Videotaped seminar on stress management for ATCSs produced.

Related Projects/Activities

- Aeromedical Program Support—will provide revised color-vision tests and standards that will become part of the ATCS selection process and related workforce studies.
- Advanced Automation System—will produce new equipment and procedures that must be considered in developing critical ATC personnel characteristics.

Schedule



12.2
Human Performance

Purpose

To enhance understanding of the human function in the complex environment of ATC and cockpit systems in support of agency rulemaking activity.

Category

D—Sustaining R,E&D Activities

Approach

Assessment of the workload and performance of ATC personnel has been a matter of active scientific study for decades. It is now possible to measure productivity and effectiveness objectively through task analyses and simulation. This project will closely monitor the progress of similar ongoing programs within the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), and industry. Extensive test facilities will be used for conducting a broad range of investigations under this project. These facilities include, among others, a vision tester for measuring ten vision parameters; a B-727 aircraft simulator; multiple task performance apparatus for evaluating responses to stress conditions; a disorientation device for assessing the effects of the interaction of motion and other stress factors on performance; and simulated controller suites for research on the effects of such factors as age, stress, and rest on controller performance. The following areas will be investigated:

- Advanced Automation—The characteristics of advanced automation and the Sector Suites will be examined, and a realistic assessment made of the associated workload. Based on a systematic data analysis, the FAA will address methods of reducing or eliminating boredom, inattention, stress, and fatigue due to fluctuations in control workload. An understanding of the allocation of pilot/controller responsibility will be crucial to this analysis.
- Controller Performance Measurement—A major initiative during 1984-85 is the development and validation of objective means for measuring controller performance. This effort will provide a baseline for future workload assessments and possibly a field evaluation tool. Feasibility studies at the Radar Training Facilities of the FAA Academy will result in a standardized computer-based system for performance measurement.
- Airman Performance Measurement—The vast majority of aircraft accidents result from a variety of pilot errors. These errors are associated with deficiencies in training, proficiency, equipment and systems design, management, and judgment. These problems of air carrier and general aviation pilot performance will be addressed. Because errors in judgment are responsible for many fatal accidents, major efforts are planned to evaluate judgment training for airmen.
- Operational Error Evaluation System—A goal of the NAS Plan is to reduce ATC operational errors by 80 percent by 1995. To accomplish this, the FAA needs enhanced techniques for accurate classification and counting of operational errors, and a fundamental understanding of their causes. This project will develop a data base on operational errors designed to identify underlying human-related causes, and to serve as a basis for both selection/training systems and the identification of possible preventive methods.

Products

- Reports describing methods for measuring controller workload and performance
- Reports describing the relationship of aging, work/rest scheduling, and other workforce variables to controller performance
- Reports on the relationship of operational errors to controller selection, training, and situational variables
- Reports on the occurrence of operational errors by location, shift, and other situational variables
- Reports on methods for training and evaluating pilot judgment

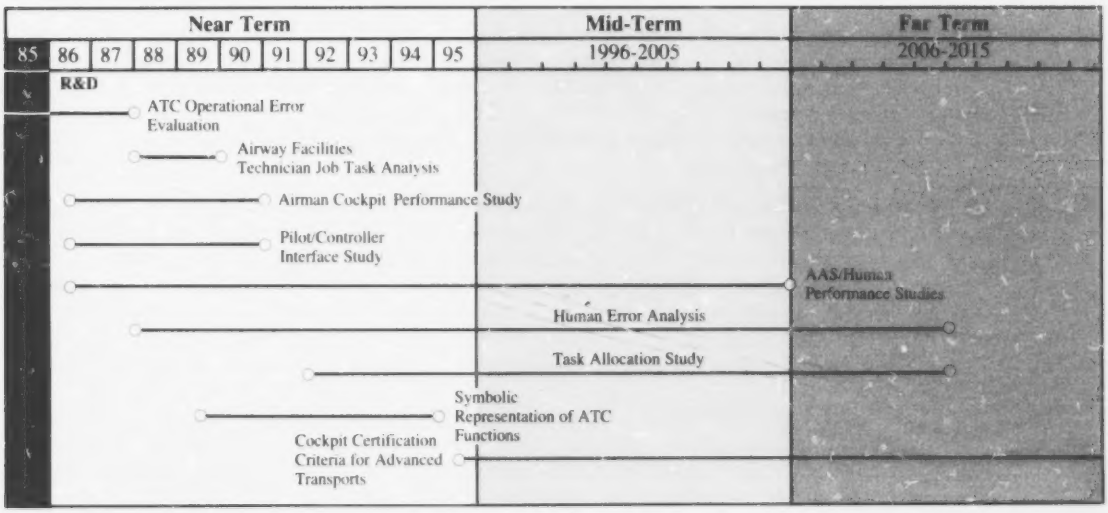
Recent Accomplishments

- Data collection phase for Eastern Region Pilot Judgment Training demonstration project completed.
- Psychological/physiological assessments in Flight Service Station (FSS) shift preference study completed.
- Data collection completed for terminal/en route job task analysis project.

Related Projects/Activities

- Aeromedical Program Support—will provide medical standards for airmen and ATCSs that may limit or enhance task performance potential.
- Advanced-Technology Cockpit—will develop new cockpit systems that will be evaluated for human performance.

Schedule



12.3
Protection and Survival

Purpose

To develop data and analysis for assessing the efficacy of concepts for protection and survival following aircraft accidents. In cooperation with airspace users and industry, this research serves to promote optimal survival concepts.

Category

D—Sustaining R,E&D Activities

Approach

Protection and survival are dependent upon the interaction of people with equipment certified or approved by the FAA. The FAA's efforts directly or indirectly relate to emergency equipment and/or procedures. Generally, the approach is twofold: first, to support rulemaking or certification actions by evaluating the merits, demerits, costs, and benefits of specific safety-related appliances; and second, to promote the proper use of these appliances through educational initiatives, in cooperation with industry and airspace users. The following areas are being investigated:

- Seats and Seat Restraints—Near-term regulatory initiatives have emphasized potential improvements in seats and restraint systems. Testing will support seat and restraint crashworthiness determinations, and validate the seat occupant model. Tests of energy attenuation concepts and the characteristics of composite-material seats will be performed during controlled full-scale impact tests. Protection requirements for side-facing seat occupants will be determined. Far-term efforts will include tests designed to provide data on new technologies. Regulatory requirements and test procedures will reflect evolving concepts of civil airman and passenger tolerance. Close cooperation with other agencies involved in parallel human tolerance efforts will be ensured.
- Water Survival—Near-term efforts will continue to focus on the development of viable and cost-effective water survival concepts and procedures. Standards for flotation platforms will be developed; seat cushion buoyancy requirements and performance criteria will be assessed in a dynamic environment. Mid-term efforts focus on airport water rescue requirements, such as aircraft and rescue equipment compatibility.
- Protective Breathing Equipment—Near-term efforts focus on improved technical standards for protective breathing equipment used by aircraft crews. The effectiveness of new criteria will be evaluated against the range-of-profile characteristics of the crew population. Tests of passenger protection will be completed. Future studies will be directed toward passenger and crew protection standards for advanced-technology aircraft.
- Toxicity—To develop reasonable standards for cabin interior materials, it is necessary to derive limits for smoke and toxic gas production. This program will continue to support the development of a small-scale toxicity test procedure that correlates with full-scale tests conducted under the Aircraft Fire Safety project. Additionally, some effort will continue on the fundamental understanding of the combined effects of irritant and toxic gases; this effort will contribute toward the development of a hierarchy of materials with respect to their human toxicity.
- Evacuation—Special studies will be conducted to support other agency development programs.

Products

- Human tolerance data and criteria to support the certification of aircraft seats and restraint systems
- Criteria to support the certification of flotation and onboard rescue equipment
- Criteria to support the certification of protective breathing equipment and operational procedures
- Criteria to support the certification of fire and smoke/toxicity limits of aircraft interiors
- Criteria to support the certification of cabin safety and evacuation (a Notice of Proposed Rule Making [NPRM] on emergency lighting has recently been issued that is indicative of the types of criteria being planned.)

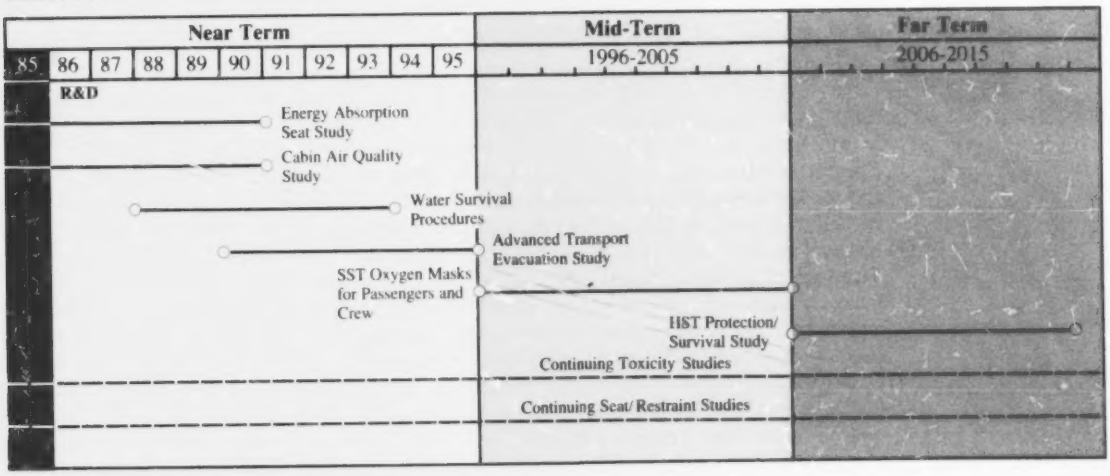
Recent Accomplishments

- Water Survival Staff Study completed, detailing recommendations on equipment and procedures for airborne and groundside environments.
- Testing of aircrew protective breathing devices completed in support of rule-making project.
- General Aviation seat/restraint test program completed that evaluated energy-attenuating designs in support of General Aviation Safety Panel (GASP) recommendations.

Related Projects/Activities

- Aeromedical Program Support—biomedical, pathological, and toxicological investigations of accidents will develop injury mechanisms required for revision of protection/survival equipment and procedures.

Schedule



12.4
Aeromedical Program Support

Purpose

To increase safety in aviation by ensuring the health of airmen through the medical certification program and educational efforts; also, to increase agency workforce efficiency by providing healthful work environments for agency employees.

Category

D—Sustaining R,E&D Activities

Approach

A series of studies will be undertaken to support the data needs of the Federal Air Surgeon:

- Aeromedical Certification and Standards—A complete review of the aeromedical standards of Federal Aviation Regulations (FAR) Part 67 will be undertaken using a body of aeromedical experts. This two-year initiative is expected to result in a series of recommendations for rule-making following the reviews required by the Administrative Procedures Act. Far-term activities will be pursued up to the report of the experts. Current activities include a study designed to evaluate the effect of therapeutic drugs on human performance, and studies using epidemiological methodology for correlating medical certification decisions with safety-related data bases to demonstrate the validity of administrative actions.
- Medical Accident Investigation—Recurring and special studies are undertaken in response to the National Transportation Safety Board (NTSB), industry, and the Federal Air Surgeon to determine potential crew incapacitation and medical factors associated with aircraft accidents. From these studies, common factors and injuries are identified and reported to support national education and regulatory actions. Far-term trends, such as incidence of elevated blood alcohol and drugs, can be assessed in this way.
- Occupational Health—Agency occupational health programs and their costs constitute a major responsibility of the Federal Air Surgeon, and require data analyses. These analyses identify the measurable benefits of special intervention programs designed to lower the cost of public services. Of particular importance are those health impacts potentially unique to FAA occupations. Special research studies will be undertaken in response to potential or alleged occupational hazards as they are identified.
- Aeromedical Education—These activities provide the mechanism for training of the FAA-designated aviation medical examiners. They also serve a valuable safety purpose in promoting nonregulatory concepts that are significant to the airman's health. Generally, airman aeromedical educational activities are directed towards classic concepts in flight physiology, aviation psychology, and aeromedical problems; additionally, special-emphasis topics, such as accident investigation, survival training, and aviation examiner seminars, are promoted.

Products

- Annual reports on alcohol- and other drug-related accidents
- Revised standards for evaluating medical criteria and procedures
- Criteria to support the regulatory process in the areas of crashworthiness and drug usage
- Toxicology of fatal accidents (continuous)
- Guidelines for processing mass casualty accidents
- Handbook on radiation levels
- Aeromedical-related pamphlets for use in the accident prevention program

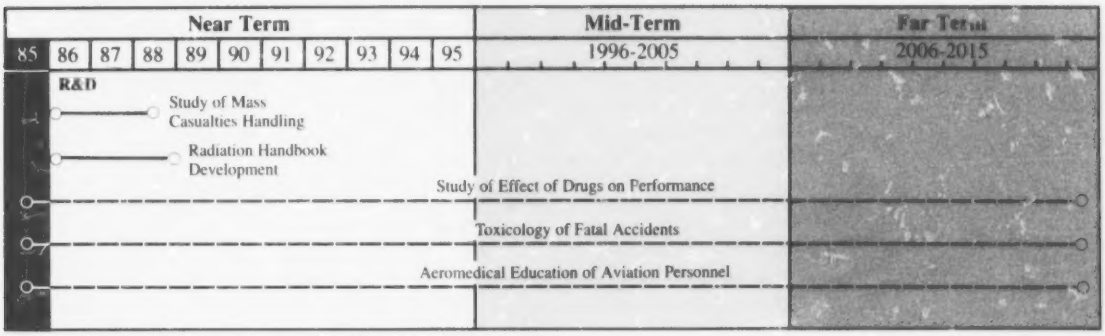
Recent Accomplishments

- Survey of 59 general aviation accidents to determine rate of shoulder harness usage completed.
- Study of aircrew radiation exposures based on representative flight profiles completed.

Related Projects/Activities

- Aircraft Systems Fire Safety—will identify new cabin-interior materials for investigation of toxicological effects.

Schedule



Chapter 13
Aviation Security

Aviation security projects will meet the anticipated threat of hijacking and terrorism by providing a balanced response with demonstrated improved procedures and equipment.

Approximately one million passengers enplaned each day are successfully screened for explosives and weapons. The objective of the aviation security R,E&D projects is to develop improved systems for the detection of explosives in air cargo, checked baggage, aircraft, and the terminal; to further improvements in concourse security; and to evaluate operationally viable responses to in-flight bomb threats. These aviation security projects are carried on at the direction of a Congressional requirement that the FAA Administrator will (Public Law 93-366) "*. . . conduct such research (including behavioral research) and development as he may deem appropriate to develop, modify, test, and evaluate systems, procedures, facilities, and devices to protect persons and property aboard aircraft in air transportation or intrastate air transportation against acts of criminal violence or aircraft piracy.*"

The sophistication of the hijacking and terrorist threats is anticipated to increase. Explosive detection will become more difficult as the diversity of commercial explosive ingredients increases. The aviation security projects are unique within the agency in that the hardware and procedures developed are implemented by the air carriers and airport operators as directed by the FAA Office of Civil Aviation Security.

Passenger screening is predicted to become more demanding in the future, requiring near-perfect detection rates for weapons and explosives, higher throughput, and very low false alarm. Growth in the number of passengers and the reduced interaction between passengers and airline personnel will dictate the rapid screening of large numbers of people. Advanced sensor technology and increased use of computer-aided analysis will allow *transparent* passenger screening.

Baggage screening will also be complicated because of increasing proportions of nonbusiness travelers and the greater diversity of baggage check-in locations, including downtown check-in at local mass transit facilities. Greater use of rotorcraft and vertical/short take-off and landing (V/STOL) aircraft will increase commuter departures from new, nonconventional airports.

System studies will be conducted to develop a balanced security program in the industry and to generate the data necessary for making implementation decisions on specific technologies. To support the program, a test facility is required that will be used to conduct hardware and procedure development, as well as testing and training in the developing improved technology for explosive and weapon detection.

The aviation security R,E&D projects are designed to meet the anticipated threat of hijacking and terrorism by providing a balanced response with demonstrated improved procedures and equipment. These projects will continue to develop new systems and procedures as warranted by the changing character of future threats.

Aviation Security Project Summary

Area	Project Number	Project Name
Detection	13.1	Concourse Security
Detection	13.2	Bulk Explosive Detection
Detection	13.3	Enhanced Bomb Detection
Operations	13.4	In-Flight Bomb Response
Operations	13.5	Security System Integration

13.1
Concourse Security

Purpose

To develop improved systems for detection of weapons and explosives in passenger/hand-carried baggage.

Category

D—Sustaining R,E&D Activities

Approach

This project is divided into four parts: detection of weapons carried by an individual, detection of explosives carried by an individual, detection of weapons and explosives in hand-carried baggage, and detection of flammable liquids. Different technologies are required to respond to the different paths of entry of hijacking weapons to the aircraft. Vapor detection is the only known method of detection for explosives carried on a person. Weapons-detection systems will be developed for improving detection and for countering any new threats. This hardware will then be tested and the results provided to the FAA Office of Civil Aviation Security (ACS) so that they can prepare recommendations for possible implementation.

Products

- Prototype hardware and testing
- Project evaluation reports
- Engineering procurement specifications
- Operational usage procedures

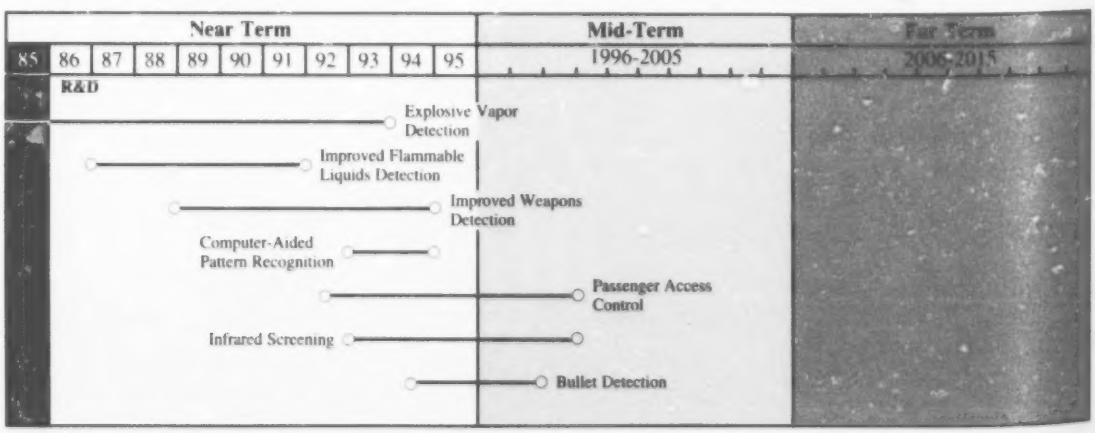
Recent Accomplishments

- Operational tests completed on an x-ray absorption system.
- Concourse x-ray specifications modified.
- Weapon detector calibration procedure developed.
- MAX E Dual Energy X-Ray evaluation completed.
- Phase I of Vapor Detection Personal Screening System development completed.

Related Projects/Activities

None

Schedule



13.2
Bulk Explosive Detection

Purpose

To develop improved systems for detecting explosives contained in checked baggage and air cargo.

Category

D—Sustaining R,E&D Activities

Approach

The detection of explosives will be based on their bulk physical properties and elemental composition. Various radiation techniques will be developed for detecting the presence of explosives in the varied background of baggage and cargo.

Products

- Prototype hardware and testing
- Project evaluation reports
- Engineering procurement specifications
- Operational usage procedures

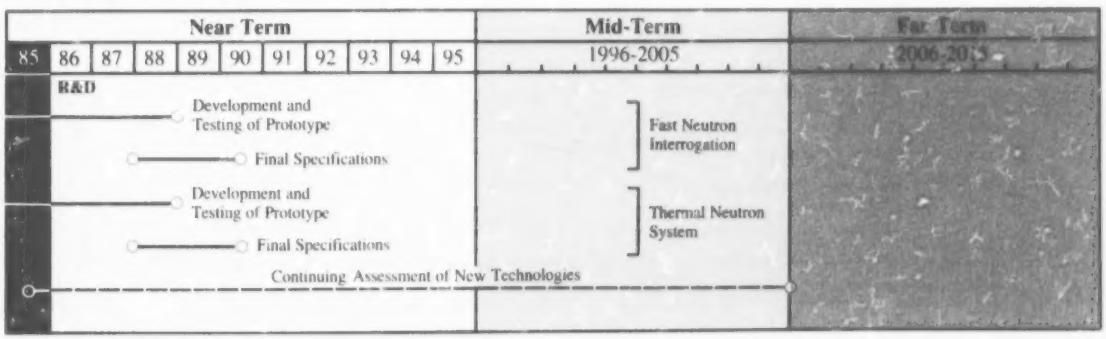
Recent Accomplishments

- Field tests on a Nuclear Magnetic Resonance System completed.
- Thermal Neutron Air Cargo tests and system specifications completed.

Related Projects/Activities

None

Schedule



13.3
Enhanced Bomb Detection

Purpose

To develop an additive and associated detection procedures that will render terrorist explosive devices readily detectable.

Category

D—Sustaining R,E&D Activties

Approach

In close cooperation with the nstitute of Makers of Explosives (IME), new additives, their incorporation, and subsequent detection procedures will be investigated. An additive will be identified for industry-wide use in the manufacture of explosive devices.

Products

- Prototype hardware and testing
- Project evaluation reports
- Operational guidelines

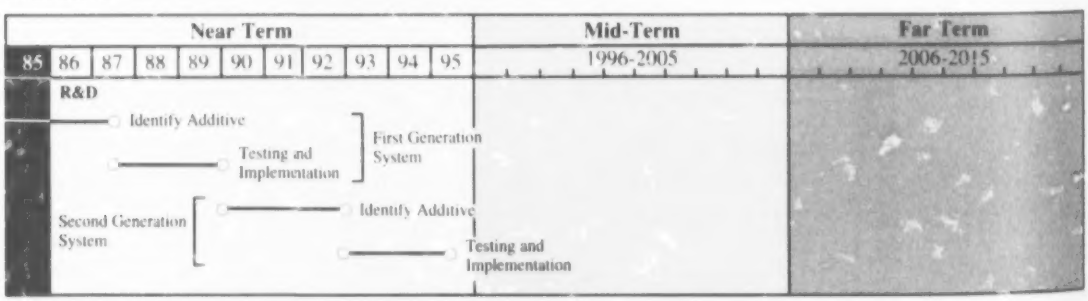
Recent Accomplishments

- Agreement with IME put in place.

Related Projects/Activities

None

Schedule



13.4
In-Flight Bomb Response

Purpose

To develop and validate procedures for a flight crew to use in dealing with an explosive device to prevent its functioning and/or the destruction of the aircraft.

Category

D—Sustaining R,E&D Activities

Approach

Aircraft structures will be analyzed in an effort to predict structural responses to onboard explosions. Actual explosion tests will then be conducted for purposes of validating these analytical studies. Techniques for handling suspected bombs and limiting damage will then be developed and evaluated for operational effectiveness.

Products

- Project evaluation reports
- Operational guidelines

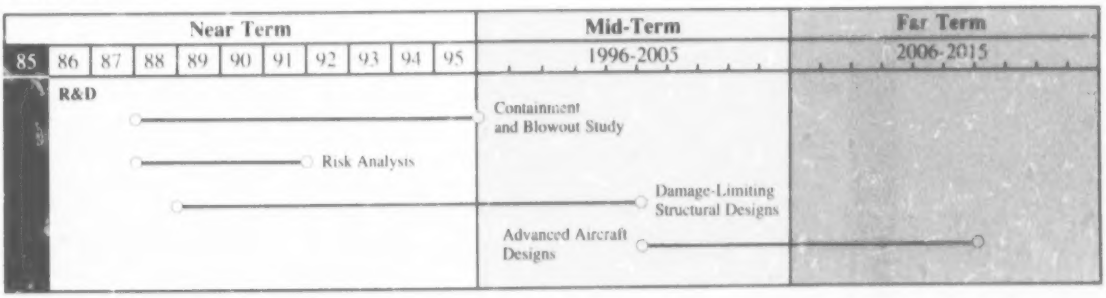
Recent Accomplishments

- Jettison feasibility study completed.
- Containment study completed.
- Risk analysis for all current large jet aircraft conducted.

Related Projects/Activities

None

Schedule



13.5
Security System Integration

Purpose

To develop an integrated airport security plan addressing all aspects of physical security whose breach would lead to the disruption of activities at an airport.

Category

D—Sustaining R,E&D Activities

Approach

It is necessary to ensure all aspects of security at the airport to preclude any windows of vulnerability. An assessment of the changing threat and of the conflicting requirements of high effectiveness and low cost will be conducted.

Products

- Prototype hardware and testing
- Project evaluation reports
- Operational guidelines

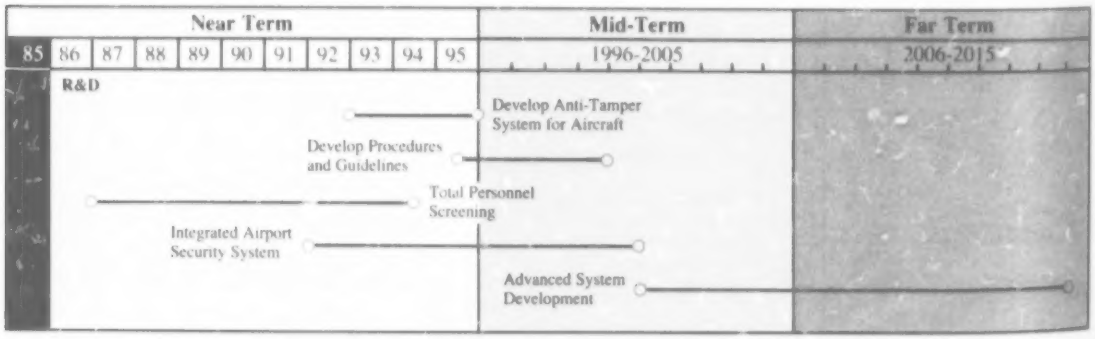
Recent Accomplishments

- Model security plan for Washington National Airport developed.
- Report on protection of airports against explosives published.
- Study of hardening of air terminals to small bomb effects completed.

Related Projects/Activities

None

Schedule



Chapter 14
Technology Development

Technology development projects will examine new or developing technology that shows promise for NAS applications.

The objective of the R,E&D technology development projects is to examine areas in new or emerging technology that show promise of an excellent return on investment for both users and providers of NAS services, or that show promise of a dramatic increase in safety. Research in many of these areas is being performed by other government agencies, such as the Department of Defense (DOD), the National Weather Service (NWS), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF), and by universities and industry. The FAA will continue to maintain awareness of these efforts and attempt to identify specific FAA applications. Some research areas are tailored to FAA needs, although some important issues will have to be resolved before potential capabilities can be realized. The projects presented in this chapter identify major areas of opportunity having a high probability of success. These projects have been grouped into three general technology development areas:

- Development of New Sensing Techniques—to detect and predict wake vortex and wind shear hazards in the airport environment
- Definition of Man/Machine Interface (MMI)—to study human factors and training simulators for Air Traffic Control Specialists (ATCS) and pilots as advanced systems and displays are introduced
- Adaptation of Developing Technology—to use voice activation for control and data entry in advanced cockpits and expert systems to enhance several NAS functions

Research in these areas would be continued until a decision can be made whether to develop a particular technology application. Results from this research may affect one or more R,E&D projects contained in other chapters of this plan. The evolution of potential improvements to the NAS resulting from these efforts is outlined in Table III. Further details are provided in the individual project descriptions.

Development of New Sensing Techniques

New sensing techniques will be investigated for two areas of interest to aviation:

- Wake vortex
- Wind shear

The presence of wake vortices behind aircraft limits the spacing between landing and departing aircraft, thus limiting capacity and causing delays. The development of better wake vortex models and forecasting techniques should make closer aircraft spacings possible most of the time. Advanced wind shear sensors and techniques are needed to detect and predict wind shear hazards reliably, and to recommend avoidance procedures.

Wake Vortex

A serious impediment to improving the capacity at major airports is the potential for an aircraft to encounter the wake vortex generated by a preceding aircraft. Considerable research has been performed by the FAA, the Transportation Systems Center (TSC), NASA, and industry in an effort to develop both technological and operational solutions to this problem. It is now possible to identify surface wind parameters that may allow reduced separations, but it is still difficult to translate this knowledge into an operational procedure that would enable controllers to reduce separations for a significant period of time. Furthermore, pilots have been reluctant to trust a system that does not directly detect the vortices. No suitable method has yet been developed for predicting the potential hazard presented by wake vortices to make reduced separations possible during instrument meteorological conditions (IMC).

Current methods of avoiding hazardous wake vortex encounters will be improved. If necessary, better procedures and separation standards may also be developed. The safety of new approach procedures, such as those made possible by the Microwave Landing System (MLS), will be evaluated. The criteria used to classify aircraft for wake vortex purposes will be improved for achieving a more efficient use of airspace while maintaining safety. Additional data on new aircraft types are needed to define optimum procedures for avoiding wake vortex hazards. The current wake vortex hazard model will also be improved so that the safety of operations at high altitudes and for small aircraft can be analyzed.

Table III
Evolution of Potential NAS Improvements

Area	Near Term 1986-1995			Mid-Term 1996-2005			Far Term 2006-2015		
	Improvement	R,E&D Project (Number)	Basis	Improvement	R,E&D Project (Number)	Basis	Improvement	R,E&D Project (Number)	Basis
New Sensing Techniques	Improved wake vortex hazard model. Improved procedures and standards.	Wake Vortex Avoidance (14.1)	C S	Method for forecasting short range (less than one hour) and mid-range (8 to 12 hours) wake vortex. Procedures for basing aircraft separation on turbulence parameters.	Wake Vortex Forecasting (14.2)	C S	Evolution		
	Develop rotorcraft wake vortex hazard model. Improved rotorcraft separation standards and advisories.	Rotorcraft Wake Vortex Avoidance (14.3)	C S	Evolution					
				Improved wind shear sensor using advanced technology devices.	Advanced Wind Shear Development (14.4)	C S	Evolution		
Man/Machine Interface	Guidelines of controller roles and responsibilities with the envisioned evolution of the new ATC system.	Evolution of Controllers' Roles (14.5)	S PP	Procedures for controller man/machine interface with the new ATC system.	Evolution of Controllers' Roles (14.5)	S PP	Evolution		
	Guidances for controller interface with new display and data entry devices.	Guidelines for Controller Displays and Data Entry (14.6)	S PP	Procedures for controller man/machine interface with new ATC displays and data entry devices.	Guidelines for Controller Displays and Data Entry (14.6)	S PP	Evolution		
	Develop data base on controller workload in the evolving new ATC system.	Controller Workload Assessment (14.7)	S PP	Evolution					
	Improvement of air carrier flight crew training.	Flight Crew Training Enhancements (14.8)	S UP	Evolution					
	Methods and criteria for certification of advanced-technology cockpits.	Behavioral Certification Criteria for Cockpits (14.9)	S UP	Evolution					
	Integration of cockpit equipments and aircrew procedures into evolving NAS.	Advanced-Technology Cockpit (14.10)	S UP	Evolution					
	Improved crew performance criteria for certification of new rotorcraft cockpit display and control equipments.	Rotorcraft Display and Control Standards and IFR Requirements (14.11)	S UP	Evolution					
	Establish criteria and guidance for FAA's evaluation of visual scene information for improved helicopter simulators.	Visual Scene Performance Characteristics (14.12)	S UP	Evolution					
	Advisory circulars defining degrees of freedom and performance levels of each degree of freedom for improved helicopter simulators.	Motion System Performance Characteristics (14.13)	S UP	Evolution					
	Mathematical model definition and aeronautical data evaluation for improved helicopter simulators.	Helicopter Modeling and Flight Test Data Requirements (14.14)	S UP	Evolution					

Adaptation of Developing Technology	Guidelines for use of voice-activated systems in cockpits and criteria for certification.	Voice-Activated Cockpit (14.15)	S UP	Procedures for operating voice-activated systems in the cockpit.	Voice-Activated Cockpit (14.15)	S UP	Evolution		
	Guidelines and specifications for enunciators for cockpits and control rooms	Enunciators (14.16)	S UP PP	Implementation of ATC enunciators in cockpits and control rooms.	Enunciators (14.16)	S UP PP	Evolution		
	Voice recognition equipment guidelines and specifications for cockpits and control rooms.	Voice Data Entry (14.17)	S UP PP	Implementation of voice recognition equipment in cockpits and control rooms	Voice Data Entry (14.17)	S UP PP	Evolution		
	Specifications for terminal Doppler radar processor and enhanced LLWAS processor using expert system techniques.	CADM-Assisted Meteorological Applications (14.18)	S C UP	Improved ability of meteorological systems to reliably detect and identify hazardous weather conditions.	CADM-Assisted Meteorological Applications (14.18)	S C UP	Evolution		
	Specifications for knowledge-based ATC system.	CADM-Assisted Air Traffic Control Techniques (14.19)	S C PP	Improved ability of ATC controllers' decision making abilities and reduced workload using CADM models and expert systems.	CADM-Assisted Air Traffic Control Techniques (14.19)	S C PP	Evolution		
	Knowledge-based testbed for training ATC controllers, traffic managers, and operations support and maintenance personnel.	CADM-Assisted Training (14.20)	S C PP	Knowledge-based systems routinely used for training of ATC controllers, managers, and support/maintenance personnel.	CADM-Assisted Training (14.20)	S C PP	Evolution		
	Specifications for fault-tolerant equipment using knowledge-based system techniques.	CADM-Assisted Maintenance and Fault-Tolerant Equipment (14.21)	S C PP	Fault-tolerant equipment using automatic diagnostic techniques with improved reliability.	CADM-Equipped Maintenance and Fault-Tolerant Equipment (14.21)	S C PP	Evolution		

C—Capacity
S—Safety
UP—User Productivity
PP—Provider Productivity

Specific meteorological conditions that would permit reduced separations for a significant period of time will be determined. Turbulence parameters such as the Richardson Number may provide such an indicator. Also, specific conditions that would permit advance scheduling of aircraft will be identified, making possible the development of a predictive system over the long term. This would involve determining the effects of meteorological parameters such as wind speed and turbulence on the generation, transport, and decay of wake vortices.

In the area of rotorcraft, the basic objective of the wake vortex project is to support the determination of separation standards for helicopters in all airspace requiring separation. Before this objective can be attained, it is necessary to determine the strength and duration of rotorcraft wakes and downwash flow fields, the susceptibility of other aircraft to upset or damage from a rotorcraft wake encounter, rotorcraft wake effects on parked aircraft, and the minimum separation between runway and helipad for independent operations. Helicopter standards can then be developed on the basis of this data.

Wind Shear

Wind shears, particularly those caused by localized wind disturbances associated with thunderstorms, constitute a serious hazard to aviation. While there are wind shears associated with inversions and fast-moving fronts, the most dangerous are those caused by highly localized downdrafts, called microbursts. Microbursts typically last a few minutes and are localized within a few thousand feet. As a result, they are difficult to detect. Some success has been attained in detecting wind shear events with sensitive radars and lasers, but their cost relative to networks of anemometers has made them less attractive.

Early efforts to use laser technology were hampered by a lack of high-power lasers that could be operated on a turn-key basis. This method will be explored further, since recent and continuing advances in laser technology indicate that these problems may soon be overcome. This technology would permit scanning of the entire approach area around the airport for wind shear events. Algorithms will be developed for recognizing wind shear events. Tests will be conducted to evaluate these algorithms. Deployment would be targeted for the early part of the 21st century.

Definition of Man/Machine Interface

The general technology development area of Man/Machine Interface (MMI) will address three topic areas:

- Air Traffic Controller Human Factors
- Cockpit Human Factors
- Helicopter Simulator Research

The existence of a technical capability does not ensure its successful use in the NAS or in the cockpit. Without careful consideration of the manner in which the new capability can be incorporated into the workload of the operator, safety and productivity can actually be reduced, rather than enhanced. Resolution of this problem of "man/machine interface" (MMI) would require that simulations be developed concurrently with the new hardware and software to ensure that operators (pilots, controllers, and other personnel) would work efficiently with any new equipment before its designs are finalized. While these human factors are taken into account in the development of NAS equipment, it may not be possible for the development contractor to consider all the issues involved. Cockpit issues are critical, including the effects on pilot workload, crew interaction, crew training, pilot-instrument information transfer methods, and display design. The FAA would develop guidelines and Technical Service Orders (TSOs) for standards for crew training. Similar issues are evident in the controllers' environment. Developments in automation will impose requirements for information and control capabilities, and for the design of displays and control devices that are quite different from those employed in the current system. Simulations for fixed-wing aircraft and rotorcraft operations would be developed or modified to incorporate developing new technologies, such as voice synthesis and recognition, controller-pilot communications via data link, and new displays. While Federal Aviation Regulations (FAR) have recently been changed to permit increased use of simulators in training programs, use of helicopter simulators has been limited to date because of their shortcomings. Existing simulators need a great deal of improvement before they can be certified for training; research will be conducted to establish these requirements.

Air Traffic Controller Human Factors

The objectives of the controller human factors projects are to guide the evolution of the controller's role in ATC, and to ensure that displays and data entry devices are appropriate to this role. Chapter 3 envisions an evolution of the ATC system wherein the role of automation expands first to advising controllers with respect to their traffic management and separation responsibilities, and later to directly performing some of the routine control functions. As automation provides new functions and performs new tasks, the functions performed by controllers and controllers' roles will change.

This evolution of controller functions must be carefully managed. New functions imply that new information must be available at the man/machine (controller/automation) interface. New information at the interface in turn implies changes in displays and data entry devices. Finally, there are implications for controller workload that must be clearly understood and managed to ensure that, throughout the automation evolution, controller workload is maintained within acceptable bounds.

The projects in the controller human factors area represent a three-step progression. First, the evolution of controllers' roles and responsibilities will be developed, including the associated MMI information requirements. Second, techniques and guidelines for controller displays and data entry devices to support these requirements will be defined. The third step will provide a continuous assessment of controller workload to ensure that the proposed evolution is feasible.

Cockpit Human Factors

Cockpit-oriented human factors research projects would support the NAS Plan and ensure that new avionics and cockpit procedures occasioned by increased automation are properly developed. Human factors issues involved in the development of the Advanced Automation System (AAS), Automated En Route ATC (AERA), the Traffic Management System (TMS), and other systems will be addressed as part of an orderly development process, not as a separate technology area. The use of artificial intelligence and human factors is treated in the computer-aided decision making projects.

Modernization of the NAS will influence pilot workload, and could be detrimental to flight safety. Additional planning and analytical efforts will address this issue during the NAS design.

Current flight deck and display certification decisions are based on the subjective assessments of FAA test pilots. Few quantitative performance standards are available for objectifying certification test results, either in terms of the pilot effort required to fly with the new equipment or the level of performance that the pilot or crew can produce with it. With new, advanced-technology, integrated cockpit systems, this problem will become especially severe. To reduce both the costs associated with the certification of new systems and the potential for pilot errors with modern integrated instrument systems, a standardized concept would be developed for improving aural and visual alerts/cautions in modern aircraft.

Advances in flight control systems are increasing pilots' responsibilities for system management and their need for information. A pilot operating with a closely coupled semi-automated flight system may not be able to afford the time, head-down status, or physical movements required to press buttons or dial knobs to update important visual displays. Voice-activated systems are being explored for cockpit use in an effort to extend the pilot's ability to control the aircraft under high-workload conditions. The FAA will monitor this effort and will develop guidelines for the use of voice-activated systems.

In the mid-term, additional ground-air controller communications will be accomplished through data transmissions. Before this can happen, some very significant man/machine interaction questions must be explored. A major program would be undertaken in an effort to determine the form of the display (aural or visual) to be used with different data elements under high-workload conditions, and in the different phases of flight.

Helicopter Simulator Research

As simulator technology has advanced, greater use has been made of simulators in both the training and evaluation of flight crewmembers. The increasing complexity and operating costs of modern aircraft, as well as the complexity and congestion of the operating environment, indicate that even greater simulator use will occur in the future. Because of the safety advantage, simulators can provide more in-depth training than can be accomplished in an aircraft, and experience has shown that the transfer of learning from simulator to aircraft has been quite favorable. In addition to safety, the use of a simulator in lieu of the aircraft results in training cost reductions, fuel conservation, and decreased adverse effects on the environment.

In recognition of the advances that have been made in simulator technology, changes to the FAR have been made to permit the increased use of "airplane" simulators in training programs. Unprecedented advances in computer technology have made possible computer-generated visual imagery systems that provide adequate displays for most training tasks. However, simulator and visual system technology and use have been applied primarily to airplanes. There has been limited use of helicopter simulators, and to date, the assessment of crewmember qualification in helicopter simulators has not been addressed in the FAR.

As technological improvements permit, the use of helicopter simulators will be expanded. It is anticipated that such improvements will occur rapidly, and that applicable regulations will be amended to extend formal credit to the use of helicopter simulators.

The FAA will establish criteria and guidance for evaluation of helicopter simulators so that they can be certified for use in training pilots.

Adaptation of Developing Technology

Two areas are addressed in this section:

- Voice Synthesis and Recognition Techniques
- Computer-Aided Decision Making

There are a number of technology areas being developed by the DOD and industry from which the FAA can benefit by adapting them to agency needs. Voice recognition technology, for example, is expected to mature to the point where machines would accept voice input from pilots and controllers and encode it for verification and transmission. Knowledge-based systems are finding application in pattern recognition, and have already been shown to be effective in identifying hazardous wind shears through the examination of Doppler radar-derived wind flow fields. These systems will find increasing application in system fault diagnosis, meteorology, and hazard identification. In each of these areas, the FAA will investigate if these techniques can be applied within the NAS. In addition, equipment specifications, documentation standards, minimum operating performance specifications for avionics, and guidelines would be developed, on the basis of thorough analysis, simulation, and evaluation.

Voice Synthesis and Recognition Techniques

Voice synthesis techniques are currently finding their way into consumer products, indicating a maturing technology. The FAA's Voice Response System (VRS) program has taken advantage of this capability in an effort to facilitate the dissemination of meteorological information to pilots. As ground-air communication increasingly takes the form of data transmissions, voice synthesis techniques will be employed in the cockpit and control room as enunciators. Avionics standards would be developed for this crucial link in the ATC system. Further, this effort will be supported by a simulation program that will establish the intelligibility of alternate techniques in the cockpit and control room environments.

Voice recognition techniques are being actively pursued by the DOD and by industry. Currently, voice recognition has been demonstrated in applications involving particular individuals, and employing discrete utterances and small vocabularies. Efforts are being made to achieve recognition of continuous speech under conditions of different voice pitches, accents, speaking rates, and noisy environments. It can be confidently anticipated that this technology will mature in the next 20-30 years to the point where controller and pilot voice communications can be instantly coded and displayed for verification. Not only will this have a profound effect on ground-air communications, but Pilot Reports (PIREPs), ATC handoffs, and the whole area of display design will be handled differently from today.

Voice activation of controls in the cockpit is already being explored for commercial and military use. Experimental voice systems are being tested in military aircraft; their use in civilian aircraft in the near future must be expected. Such techniques may prove essential in view of increasing pilot responsibilities for system management as a consequence of advances in flight control systems. To ensure the safe use of this technology in aviation and support its constructive advancement by industry, the FAA will monitor the development of voice recognition systems for cockpit use in order to identify and certify safe systems when they appear.

Computer-Aided Decision Making

The projects in this area are structured to include technical investigations, and will yield recommendations on the potential mid- and far-term benefits of applying computer-aided decision making (CADM) techniques to the cockpit and the ATC system. Efforts include the assessment of potential applications of artificial intelligence (AI) software techniques for augmenting the role of humans in a highly automated ATC system of the future. AI research is presently being conducted by several agencies, such as the Defense Advanced Research Projects Agency (DARPA) and NASA, industry, and universities. The FAA will continue to monitor and support these efforts.

Expert systems techniques are already finding application in the interpretation of weather radar images. Microburst-type wind shears have been successfully identified with these techniques, using wind flow field data. As "expert" capabilities develop, additional sources of data, such as pressure readings, will be used to refine and expand the rule base. These techniques are expected to improve wind shear detection through the Low-Level Wind Shear Alert System (LLWAS), terminal Doppler radar, and laser scanners. Wake vortex detection techniques will also benefit. Not only will there be an improvement in detection and false alarm rates, but the knowledge of the location and motion of the dangers will permit appropriate actions to be recommended.

Additionally, support for the advanced phases of TMS will include the development of traffic management tactics and strategies based on expert systems techniques, using testbeds designed for this purpose. At the national level, a testbed will be implemented so that specifications can be developed for an advanced Central Flow Control (CFC) automation system that will (1) be cognizant of traffic demand and conditions throughout the NAS, (2) interface with AAS/AERA functions, (3) alert national traffic flow controllers to the location and magnitude of projected congestion, (4) provide recommended courses of action, (5) evaluate alternative traffic management strategies, and (6) disseminate appropriate traffic flow restrictions associated with a selected strategy. In addition, this automation system will provide traffic flow information to users through an interface with Flight Service Station automation systems, and provide system performance analysis data as an input to FAA policy and decision making. Testbed efforts will also provide a mechanism by which Sector Suite technology can be evaluated for use by CFC.

The testbed that will be developed to evaluate various tactics and strategies will also form a natural training facility, whereby novice controllers can benefit from the experience of expert controllers. This knowledge base will improve the quality of training and possibly shorten the training time required.

The FAA is currently exploring fault-tolerant systems and automatic diagnostics. Although the results of this research may not find near-term application in the ATC system, research into use of this technology for practical remote monitoring and maintenance (RMM) could yield considerable benefits. The payoff in reduced outage times, improved operational efficiencies, and reduced manpower requirements is potentially high. The FAA's current approach uses empirical solutions derived from a statistical history of problems, performance degradation, and outages, and the identification of certain precursor indicators that may indicate the likely occurrence of certain failures. There is considerable evidence that such indicators occur prior to some failures. The scheduling of preventive maintenance based on identification of these indicators may be used to achieve near-100% availability.

Technology Development Project Summary

Area	Project Number	Project Name
Wake Vortex	14.1	Wake Vortex Avoidance
	14.2	Wake Vortex Forecasting
	14.3	Rotorcraft Wake Vortex Avoidance
Wind Shear	14.4	Advanced Wind Shear Sensor Development
Air Traffic Controller Human Factors	14.5	Evolution of Controllers' Roles
	14.6	Guidelines for Controller Displays and Data Entry Devices
	14.7	Controller Workload Assessment
Cockpit Human Factors	14.8	Flight Crew Training Enhancements
	14.9	Behavioral Certification Criteria for Cockpits
	14.10	Advanced-Technology Cockpit
	14.11	Rotorcraft Display and Control Standards and IFR Requirements
Helicopter Simulator Research	14.12	Visual Scene Performance Characteristics
	14.13	Motion System Performance Characteristics
	14.14	Helicopter Modeling and Flight Test Data Requirements
Voice Synthesis and Recognition Techniques	14.15	Voice-Activated Cockpit
	14.16	Enunciators
	14.17	Voice Data Entry
Computer-Aided Decision Making (CADM)	14.18	CADM-Assisted Meteorological Applications
	14.19	CADM-Assisted Air Traffic Control Techniques
	14.20	CADM-Assisted Training
	14.21	CADM-Assisted Maintenance and Fault-Tolerant Equipment

14.1
Wake Vortex Avoidance

Purpose

To improve current methods of avoiding hazardous wake vortex encounters by adopting general separation standards and procedures that more accurately reflect the actual hazard, and by adapting the separations to the real-time duration of the hazard.

Category

C—NAS Enhancement

Approach

In this project, ways of classifying aircraft for wake vortex purposes will be examined. Wake vortex data on new aircraft types will be collected. Possible operational alternatives will be examined in light of current wake vortex knowledge and available technology, such as the MLS, for aircraft guidance. The current wake vortex parallel runway approach computer model will be enhanced to include all instrument approach options, including MLS. Associated safety analyses will be carried out, and a vortex hazard model will be developed that includes aircraft altitude and pilot response time. Wake vortex data currently not available will be collected, including data on high-altitude and parallel runways.

Products

- Enhanced wake vortex computer model
- Report on wake vortex classification of aircraft
- Report on safety analyses
- Vortex hazard model
- Vortex hazard model software and report
- Vortex behavior data report
- Recommendations for improved procedures and standards

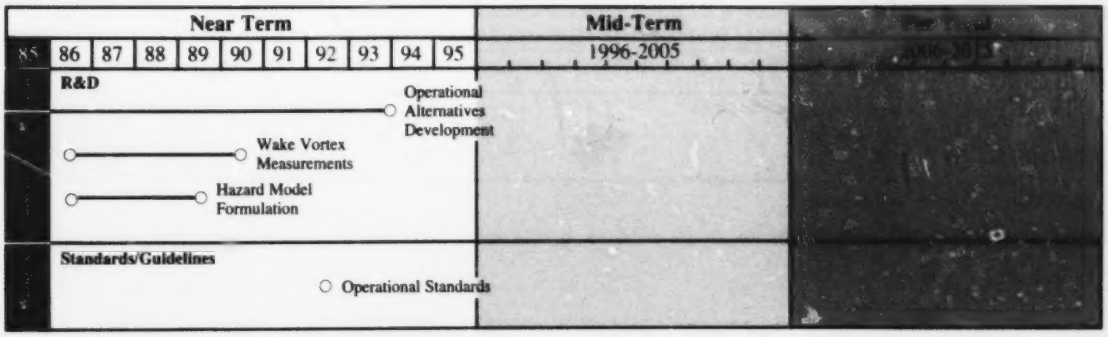
Recent Accomplishments

- Localizer Directional Approach (LDA) analysis conducted.
- Wake vortex computer model for parallel runway approach evaluations developed.

Related Projects/Activities

- Wake Vortex Forecasting—will provide accurate and timely wake vortex forecasts.
- Precision Approach and Landing—will provide certified flexible MLS approaches.
- Wake Vortex Avoidance Procedures (NASA-Ames)—different glide slope paths to a given runway and Heads Up Display (HUD) applications will be investigated.

Schedule



14.2
Wake Vortex Forecasting

Purpose

To forecast changes in the duration of the wake vortex hazard so that aircraft separation changes and airport capacity can be known in advance.

Category

E—New Initiatives

Approach

The meteorological factors affecting wake vortex behavior will be identified. The dependence of wake vortex behavior upon the Richardson Number and other turbulence parameters will be examined. Methods for the short-range forecasting (less than 1 hour) of wake vortex meteorological parameters will be developed. Methods for the mid-range (8 to 12 hours) forecasting of these parameters will also be developed, and mid-range forecasting will be added to traffic management.

Products

- Report on feasibility of basing aircraft separation on Richardson Number
- Short-range wake vortex forecasting software
- Mid-range wake vortex forecasting software

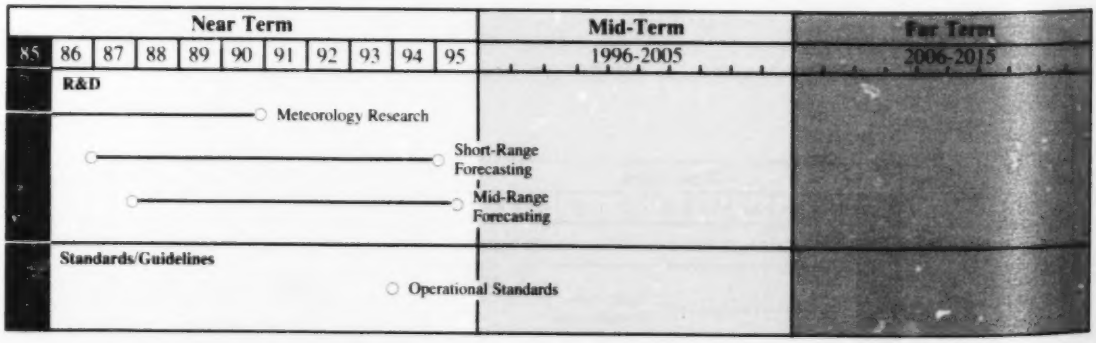
Recent Accomplishments

- Report on effects of wind on vortex decay produced.

Related Projects/Activities

- Weather Processing—provides improved short-range forecasts and total weather information.
- Mode S Data Link Applications Development—provides the means for communicating the timely forecasts to the user.

Schedule



14.3
Rotorcraft Wake Vortex Avoidance

Purpose

To support rotorcraft separation standards by obtaining information on rotorcraft wakes and upset criteria.

Category

C—NAS Enhancement

Approach

Data will be collected on the intensity and duration of rotorcraft wake and downwash flow fields. An analytical model for the rotorcraft hazard in wake vortex encounters will be developed, and validated with flight tests. Draft separation standards for rotorcraft operations will be prepared.

Products

- Report on rotorcraft wake and downwash measurements
- Report on rotorcraft wake vortex hazard model
- Recommendations for improved rotorcraft separation standards and advisories

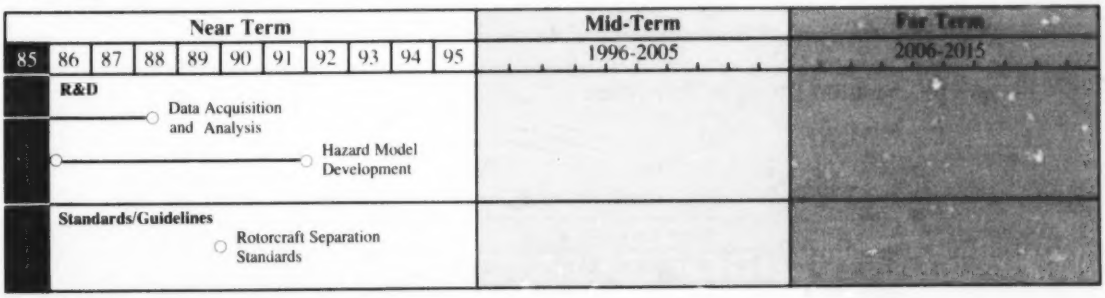
Recent Accomplishments

- Helicopter wake velocity measurements report produced.

Related Projects/Activities

- Wake Vortex Avoidance—wake vortex classification criteria and hazard models will form a baseline for rotorcraft efforts.

Schedule



14.4
Advanced Wind Shear Sensor Development

Purpose

To perform research on the measurement of wind fields using advanced-technology sensors, such as high-power carbon dioxide lasers, to determine their effectiveness in an operational airport environment; if costs and performance warrant, to develop such a sensor for airport deployment.

Category

E—New Initiatives

Approach

Research will be performed on carbon dioxide laser Doppler clear-air wind returns. Progress in the achievement of inexpensive, turn-key capability in this technology will be monitored. If other techniques are not found to provide a sufficiently high detection/false alarm capability, an experimental wind shear sensor will be developed, and field tests performed. Based on an analysis of the test results, a prototype advanced-technology wind shear sensor will be developed for eventual deployment in airports, either as a stand-alone system or as part of a system.

Products

- Report on feasibility of laser detection of wind flow fields
- Report on feasibility of inexpensive, turn-key laser systems
- Report on experimental sensor design
- Report on evaluation of experimental sensor
- Specification of prototype sensor
- Prototype sensor
- Report on evaluation of prototype sensor

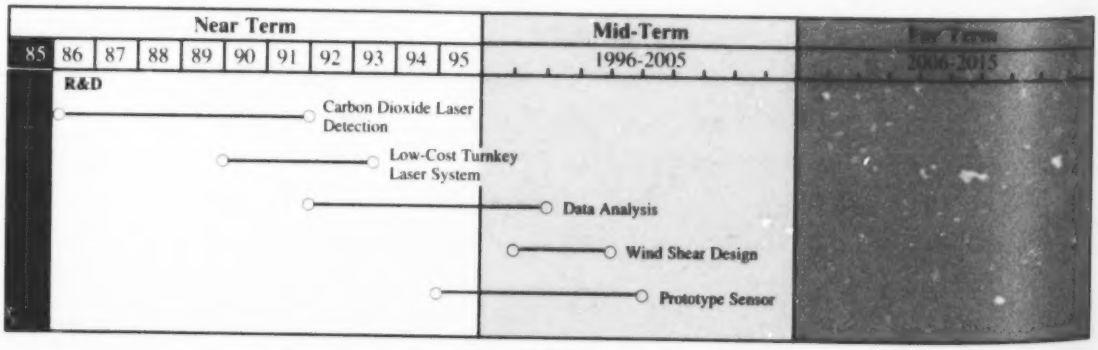
Recent Accomplishments

- Preliminary feasibility study of laser wind shear detection conducted.

Related Projects/Activities

None

Schedule



14.5
Evolution of Controllers' Roles

Purpose

To develop concepts of controller roles and responsibilities that are compatible with the envisioned evolution of the ATC system, and to define the corresponding evolution of MMI information requirements.

Category

C—NAS Enhancement

Approach

The envisioned evolution of the ATC system described in Chapter 3 provides the baseline scenario for developing the evolution of controller roles and responsibilities in the ATC system. Controller roles can be developed through analysis of the sum total functions that must be provided by ATC; these functions can then be allotted to the man (controller) or machine (automation) in accordance with the envisioned automation evolution and analyses of tasks more appropriate for assignment to the man as opposed to the machine. This rational allocation of roles is complicated somewhat by concern over certain responsibilities being assigned to automation; thus while some function, such as maintenance of en route separation, might be assigned to automation, there would be reticence to assign the associated responsibility wholly to the machine. In such cases, the controller would be assigned the responsibility for monitoring automation performance, and the necessary information to support this responsibility would have to be available at the MMI.

The principal techniques for developing the evolution of controller roles and responsibilities are analytical. They are based on an understanding of the controllers' operational environment, as well as human factors concepts related to the division of roles between man and machine. After roles and responsibilities have been defined, the development of interface information requirements will necessitate analysis and limited human factors experiments.

Products

- Periodic reports on the foreseen evolution of controller roles and responsibilities

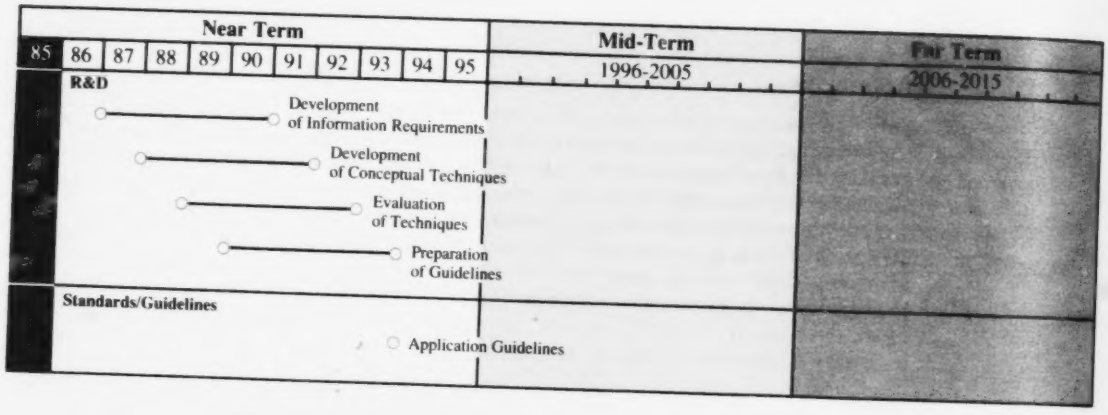
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Advanced Automation System—man/machine interface studies will be performed in the transition to the AAS Sector Suites.
- Guidelines for Controller Displays and Data Entry Devices— addresses human factors for display and data entry device designs in automated systems.
- Controller Workload Assessment—develops a metric for the measurement of controller workload to assess the impact of evolving ATC automation.

Schedule



14.6
Guidelines for Controller Displays and Data Entry Devices

Purpose

To develop guidelines for controller displays and data entry devices in support of defined MMI information requirements.

Category

C—NAS Enhancement

Approach

Technology advances offer new display and data entry devices that may have application to the evolving controller-automation interface. In particular, color displays and synthetic voice offer extended display capabilities, while voice recognition systems and touch panels may simplify data entry.

The development of guidelines for displays and data entry devices is principally an experimental activity that will utilize both conventional- and emerging-technology displays/devices. Experiments will include small-scale efforts focused on subsets of the information processed at the controller-automation interface. In particular, such efforts will be required in extending the interface to support new automation functions. Larger-scale experiments utilizing the integrated interface will be used to fully validate new display and data entry devices in acomprehensive operational context.

Guidelines will generally be in one of two forms. Technical guidelines prescribe small-scale characteristics of displays and data entry devices, such as how colors should be used, character sizes for displays, and arrangements of keys on keyboards. Implementation guidelines, on the other hand, describe an acceptable implementation of a specific interface supporting a well-defined information set. Together these guidelines fully describe the displays and data entry devices used in the implementation.

Products

- Technical guidelines for displays and data entry devices
- Implementation guidelines for specific MMI information requirements

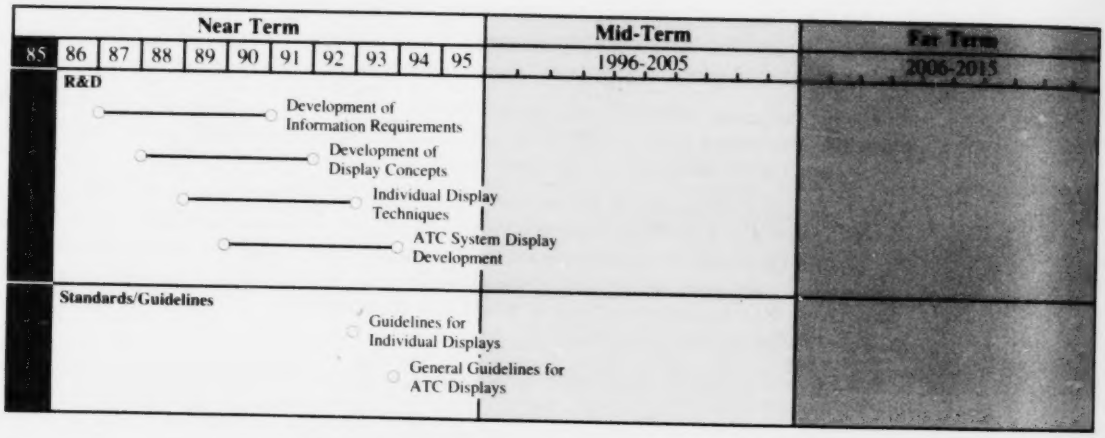
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Evolution of Controllers' Roles—details the changing roles of the air traffic controllers in the highly automated ATC system being developed.
- Controller Workload Assessment—develops a metric for the measurement of controller workload as new displays and data entry devices are being developed.
- Formal Method for Human/Computer Interface Design (NASA)—develops general design tools for analyzing and designing interfaces.

Schedule



14.7
Controller Workload Assessment

Purpose

To assess controller workload in the evolving ATC system.

Category

C—NAS Enhancement

Approach

The role (tasks) assigned to the controller, the means (displays and data entry devices) provided to support that role, and the traffic levels to be serviced combine to impose a certain workload level on the controller. It is necessary to ensure that this workload remains within acceptable bounds as the ATC system evolves. There are three essential steps involved in assessing the acceptability of controller workload: (1) developing measures of workload, (2) determining acceptable workload levels in terms of the measures developed, and (3) assessing workload levels that would be imposed by the foreseen evolution.

Aviation medicine projects described in Chapter 12 include activities for measuring controller performance and determining maximum acceptable workload levels. In addition, the Guidelines for Controller Display and Data Entry Devices project will perform comprehensive simulation experiments of the controller interface. Clearly, workload assessment should be included in these simulations. This project will extend the earlier and ongoing efforts of the aviation medicine projects to develop workload measures and limits, and will perform workload assessments in support of experiments undertaken to develop display and data entry device guidelines. The workload information developed will be maintained in a comprehensive data base to provide a national reference with respect to controller workload levels in the evolving ATC system.

Products

- Controller workload measures
- Reports on controller workload for specific controller interface configurations
- Data base on controller workload in the evolving ATC system

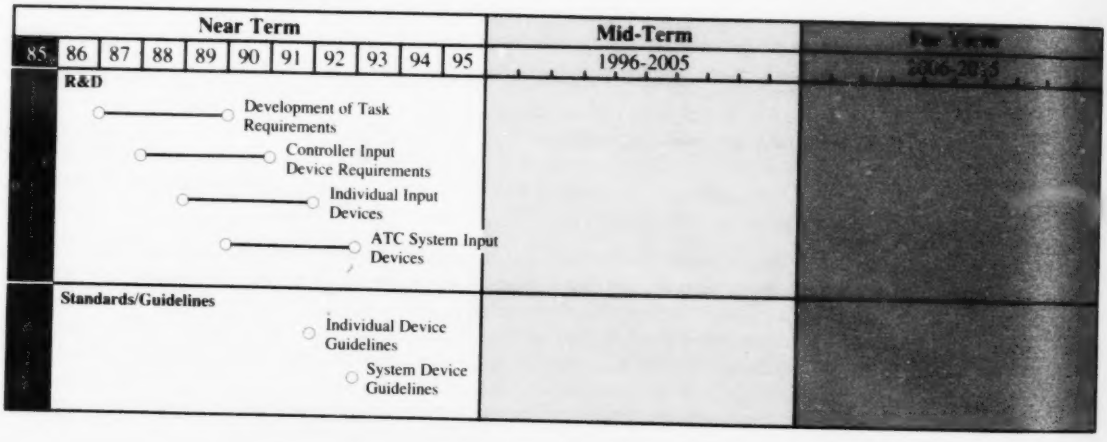
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Evolution of Controllers' Roles—details the changing roles of the air traffic controllers in the highly automated ATC system being developed.
- Guidelines for Controller Displays and Data Entry Devices—simulates the changing controller-automation interface in the evolving ATC system.
- Human Performance—develops an objective means of assessing controller performance.
- Heart Rate as a Workload Metric (NASA)—improves existing techniques for measuring workload.

Schedule



14.8
Flight Crew Training Enhancements

Purpose

To upgrade flight crew training programs in an effort to (1) increase crew skill in reverting from automated to manual flight operation during equipment malfunctions; (2) increase the effectiveness of line-oriented flight training for the training of crews in emergency procedures; (3) improve the effectiveness of communications and coordination between cockpit and cabin crews to increase flight safety and passenger comfort; and (4) decrease the cost of flight crew training.

Category

C—NAS Enhancement

Approach

The need for training enhancements will be validated and characterized through interviews, observations, and safety data analyses. Guidelines for improved programs will be developed, and prototype programs will be developed and tested. Criteria for acceptable program enhancements will also be developed. Minimum fidelity levels required in simulators used in various programs will be determined conceptually and validated experimentally. The degree to which the approach to identifying fidelity requirements can be generalized will be determined through test and evaluation in a wide variety of operational training situations.

Products

- Recommendations and guidelines for the enhancement of air carrier flight crew training performance
- Report on validated model of upgraded flight crew training program

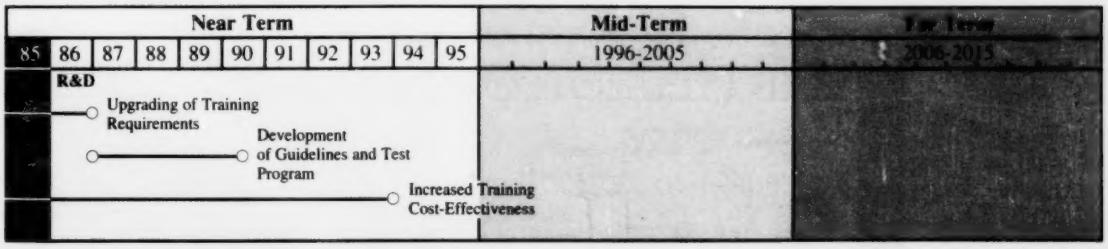
Recent Accomplishments

- Minimum fidelity levels of simulators selected for testing identified.

Related Projects/Activities

- Error-Tolerant Crewstations (NASA-Ames)—develops automatic detection of procedural errors.

Schedule



14.9
Behavioral Certification Criteria for Cockpits

Purpose

To develop methods and quantitative behavioral criteria for certifying advanced-technology cockpit display and control systems.

Category

C—NAS Enhancement

Approach

System performance requirements, including performance time and error limits, will be identified and quantified. Methods will be developed for determining the mental and manual effort required by flight crews to operate prototype systems according to performance criteria. Simulation flight scenarios will also be developed, to be used as standard flight scenarios for evaluating cockpit designs. The usability and validity of behavioral criteria and methods for certifying cockpit display and control systems will be verified.

Products

- Report on crew performance criteria for use in updating FAA Order 8110.8, "Engineering Flight Test Guide for Transport Category Aircraft"
- Guidelines for the development of displays and controls that satisfy certification criteria based on pilot performance
- Draft advisory circular for an objective workload assessment methodology acceptable for cockpit certification

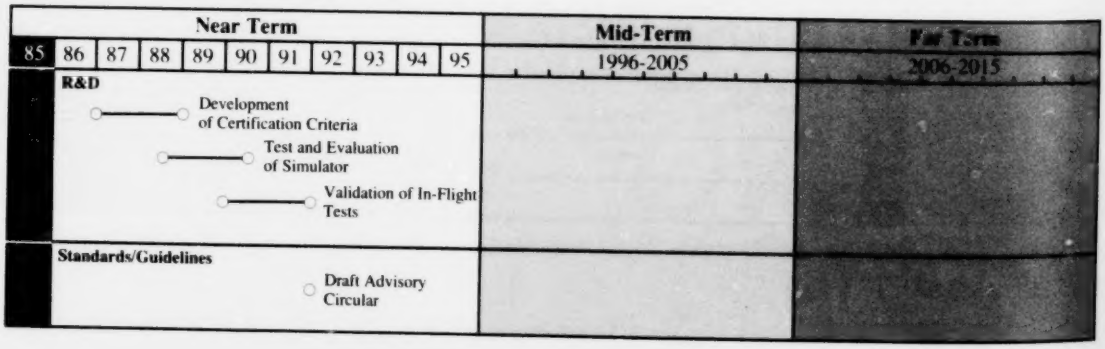
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Human Performance—provides data on the impact of cockpit display and control designs on crew workload.
- Advanced-Technology Cockpit—identifies cockpit instrument design features that could increase the risk of pilot error.

Schedule



14.10
Advanced-Technology Cockpit

Purpose

To ensure flight crew ability to use and control manual and automated flight control systems in an increasingly demanding aviation environment, and to ensure that the evolving NAS and advanced-technology cockpit are developed cooperatively and are compatible.

Category

E—New Initiatives

Approach

Problems that developments in the NAS will impose on flight crews will be identified. Among these are management of the increasing amounts of information that will be made available to flight crews, and the decreasing tolerance for error of anticipated air traffic systems. Potential solutions include the development of integrated display and control systems designed to increase the rate and accuracy of the transfer of flight control information from cockpit displays to flight crews and back to cockpit flight control systems. Flight deck information and control configurations will be tailored to crew and operational priorities and information-processing characteristics.

Products

- Report on objective and quantitative measures for evaluating crew performance with prototype displays
- Guidelines for display formatting and integration to increase information location, comprehension, and application
- Report on advanced instrument control techniques that reduce the need for pilot attention, as well as pilot workload and error
- Report on the inventory of information required in the cockpit of aircraft operating within the evolving NAS
- Draft procedures for ensuring that NAS and cockpit developments are compatible and promote increases in flight safety

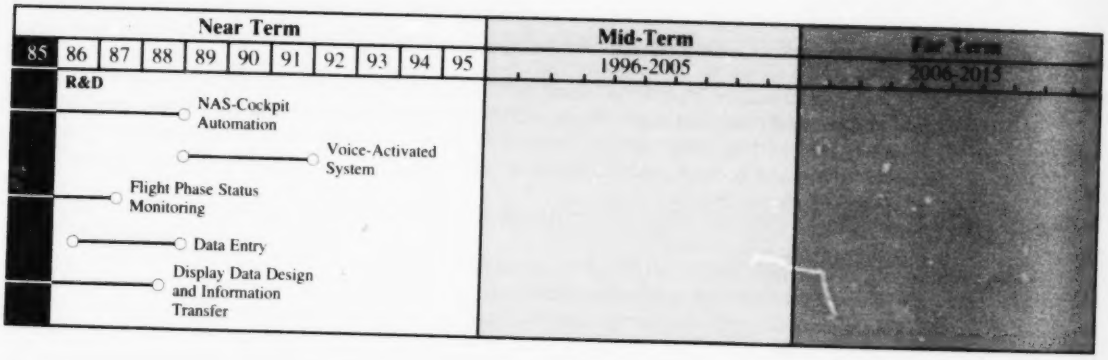
Recent Accomplishments

None

Related Projects/Activities

- Human Factors Principles in Automation (NASA-Ames)—provides guidelines for designs of automated systems.
- Flight Management Research and Technology Objectives and Plan (NASA-Langley)—explores automation techniques that enhance flight safety and efficiency.
- Advanced Voice Recognition Systems (USAF)—the U.S. Air Force Flight Development Laboratory is developing voice recognition systems that will recognize a pilot's verbal commands.
- Voice Synthesis and Recognition Techniques—explores the use of voice generation and recognition techniques for cockpit and ATC applications.
- Direction Judgments Using Spatial Displays (NASA)—studies "field of view" on displays to determine operators' best performance relative to spatial displays.

Schedule



14.11
Rotorcraft Display and Control Standards and IFR Requirements

Purpose

To develop behavioral (crew performance) criteria that can be used to evaluate and certify new cockpit display and control technology.

Category

C—NAS Enhancement

Approach

The current state of the art in flight performance assessment and cockpit technology will be reviewed. Current and anticipated rotorcraft operational requirements and developments in display and control technology will be assessed. In addition, information requirements and task analyses of critical Instrument Meteorological Conditions (IMC) flight operations will be conducted, and crew/rotorcraft performance standards will be developed for selected representative performance- critical rotorcraft operations.

Products

- Report on characterization of performance-critical rotorcraft operations
- Report on rotorcraft visibility and crew information transfer requirements
- Report on crew performance issues requiring special attention
- Report on human performance criteria for use in cockpit certification

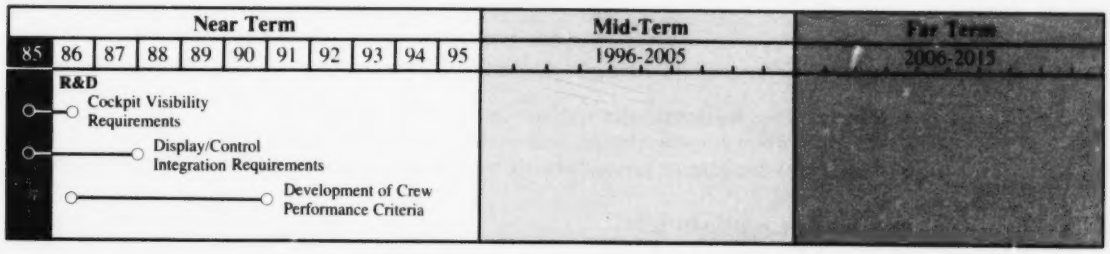
Recent Accomplishments

None

Related Projects/Activities

- Helicopter Simulator Research—provides means of evaluating different display designs.

Schedule



14.12
Visual Scene Performance Characteristics

Purpose

To establish the necessary criteria and guidance for the FAA's evaluation of the visual scene in a helicopter simulator to be used for training programs or for crewmember checking. The major problems observed in helicopter simulator characteristics are in the hover and low-speed flight phases. These problems are manifested by pilot induced oscillations in height control, which in turn cause control problems laterally and longitudinally. These control problems may result from the pilot's having insufficient visual information from which to detect small changes in translational displacement and velocity and in height. While the causes of these problems have not been positively identified, it is suspected that the performance of the visual system and the available scene content could be major factors.

Category

E—New Initiatives

Approach

This project includes the following areas of activity:

- Field-of-View Requirements—This will include an evaluation of the minimum field-of-view requirements, both vertically and horizontally, for providing sufficient visual cueing so that the pilot can perform hover and forward flight maneuvers typical of those required for pilot certification. The need for a lower chin window should be investigated for its value in meeting these requirements, for both single- and two-pilot operations.
- Visual Scene Detail—This evaluation will address the minimum visual scene detail required, including scene resolution, color, brightness, texture, depth of field (focus), and the types of objects or features that best give the pilot relative motion cues with respect to the ground in the visual scene. Consideration should be given to the maximum visibility range required (less than 50 miles) to allow the generation of maximum scene detail in the near vicinity of the helicopter.
- Visual System Transport Delay (Time Lag)—This effort will address the minimum time lag allowable with no effect on the pilot's ability to control the vehicle without causing pilot-induced oscillations (PIOs). It may be of value to use knowledge of the vehicle's velocity and accelerations in forming lead compensation, or to use predictive integrations techniques in canceling a portion of the visual system's design time lag.

Products

- Report on the horizontal and vertical field-of-view analysis
- Analysis of the amount, degree, and quality of a visual scene report
- Analysis of the latency period between a pilot input and response of the visual system report

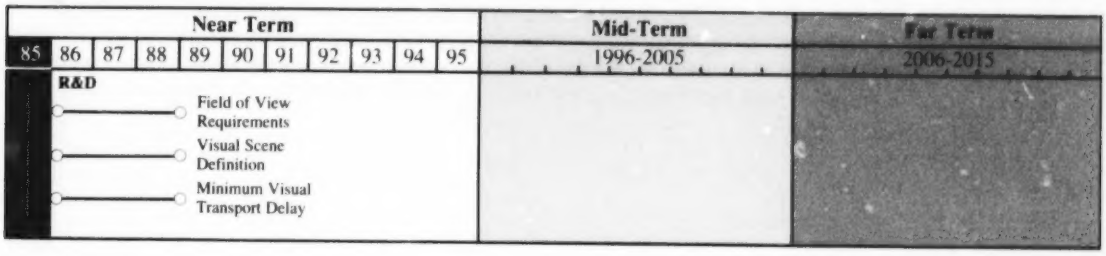
Recent Accomplishments

- Draft produced of a "Helicopter Simulator and Visual System Evaluation" Advisory Circular to be used for helicopter simulator visual scene performance validation.

Related Projects/Activities

- Rotorcraft Wake Vortex Avoidance—provides definitions and specifications for rotorcraft wake vortex and downwash flow fields.

Schedule



14.13
Motion System Performance Characteristics

Purpose

To establish the necessary criteria and guidance for the FAA's evaluation of the motion system performance characteristics of a helicopter simulator to be used for training programs or for crewmember checking. As with the visual system, the contribution of motion system characteristics to the major problems of helicopter simulator performance is well known. Motion system performance is considered a potential major cause of problems with handling qualities, and may require more thorough specification than is needed for airplane simulators.

Category

E—New Initiatives

Approach

The performance areas in need of investigation and the required research are as follows:

- Degrees of Freedom Required—This will include the evaluation of the minimum degrees of freedom in the motion system required to give the pilot the appropriate cueing for satisfactorily controlling the vehicle. This analysis should include consideration of both alerting acceleration cues and feedback to pilot action cues.
- Performance Level of Each Degree of Freedom Required (Travel Limits, Frequency Response, Time Delay, etc.)—This will include evaluation of the minimum performance level of each degree of freedom required to give the pilot the appropriate cueing for satisfactorily controlling the vehicle. Important considerations in this task include the motion cues required to alert the pilot that action on his part is required, and the appropriate motion environment for effectively controlling the vehicle.
- Definition of Optimum Drive Algorithms—Current helicopter motion drive algorithms will be evaluated in light of the performance-level concerns discussed above. The drive techniques used should be considered in terms of the flight phase; that is, the drive techniques for the flying in-ground effect phase of flight may be different than those for the flying out-of-ground effect phase of flight. It is highly possible that the current techniques being used are minor modifications of those developed for airplanes and may not be appropriate for helicopters, requiring the development of a completely new approach.
- Synchronization with Visual System Performance Requirements— Critical to the foregoing evaluations and analysis is the synchronization between motion cueing and visual cueing. While each has its own problem areas to be researched, synchronization of the two cannot be ignored. An analysis defining the appropriate relationships between motion and visual cueing is a necessary requirement for the final development of qualification criteria for helicopter simulators.

Products

- Draft Advisory Circular defining degrees of freedom needed to provide disturbance and maneuver cues
- Draft Advisory Circular defining performance levels of each degree of freedom

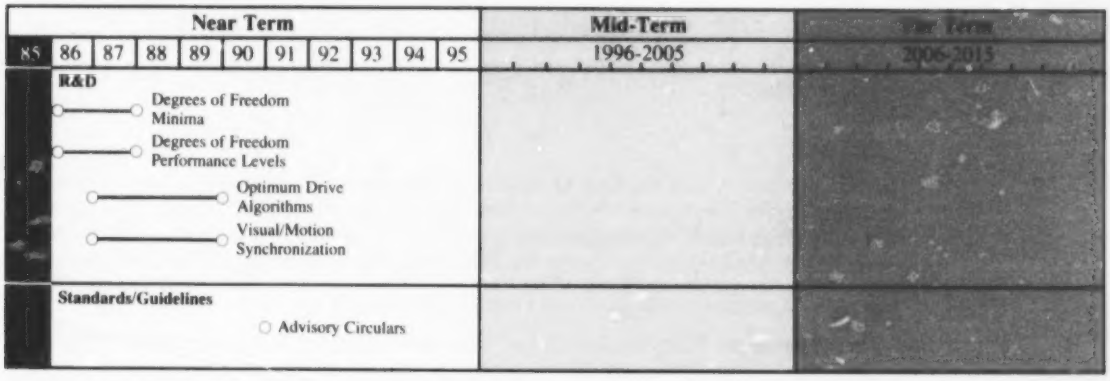
Recent Accomplishments

- Draft produced of a "Helicopter Simulator and Visual System Evaluation" Advisory Circular to be used for helicopter simulator motion system performance validation.

Related Projects/Activities

- Rotorcraft Wake Vortex Avoidance—provides definitions and specifications for rotorcraft wake vortex and downwash flow fields.

Schedule



14.14
Helicopter Modeling and Flight Test Data Requirements

Purpose

To establish the necessary criteria and guidance for the FAA's evaluation of helicopter simulators.

Category

E—New Initiatives

Approach

An area potentially constraining the fidelity of helicopter simulators is the lack of correct mathematical modeling and of appropriate flight test data for helicopters, especially for flying in-ground effect. A review of the literature shows fragmented data. For example, the effects on rotor blades of operating near the ground are reported, but no treatment of the total in-ground effect operation of the vehicle is available.

The areas in need of investigation and research are as follows:

- Definition of the Mathematical Model—Current helicopter mathematical models used in simulators will be evaluated, especially for the flying in-ground effect, with any deficiencies identified.
- Determination of Deficiencies in Available Aeronautical Data—The adequacy of available aeronautical data for helicopter simulators will be evaluated, especially for in-ground effect flight and hover. Where there are inadequacies, a test program will be developed for determining how to collect the required data.

Products

The following definitions, relationships, and deficiencies will be determined and summarized in reports:

- Optimum drive algorithms
- Motion and visual cueing relationships
- In-ground effect and hover mathematical models
- Deficiencies in available aeronautical data

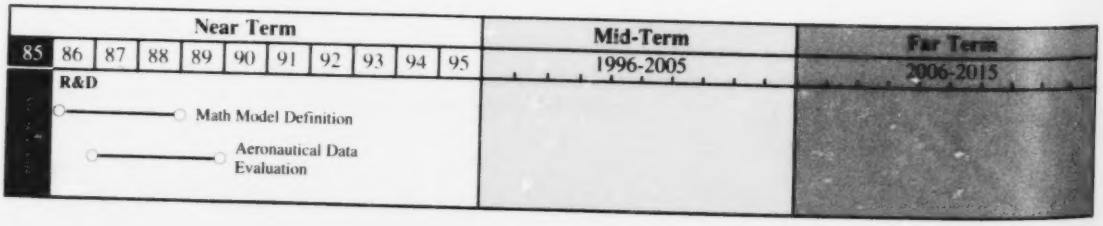
Recent Accomplishments

- Draft produced of a "Helicopter Simulator and Visual System Evaluation" Advisory Circular to be used for helicopter modeling validation.

Related Projects/Activities

- Motion System Performance Characteristics—provides specification data for modeling.
- Visual Scene Performance Characteristics—provides specification data for modeling.

Schedule



14.15
Voice-Activated Cockpit

Purpose

To develop guidelines for the use of voice-activated systems in aircraft cockpits and performance criteria for the certification of such systems.

Category

E—New Initiatives

Approach

Similar efforts by DOD, NASA, and industry will be reviewed and monitored. Cockpit applications of voice activation will be identified, and research will be performed on the effectiveness of voice activation in high-workload situations. Simulations will be conducted in operational environments, and flight tests performed with voice-activated controls.

Products

- Report on simulation design
- Report on flight test evaluation
- Guidelines for voice-activated controls
- Draft advisory circular on voice-activated cockpit instruments

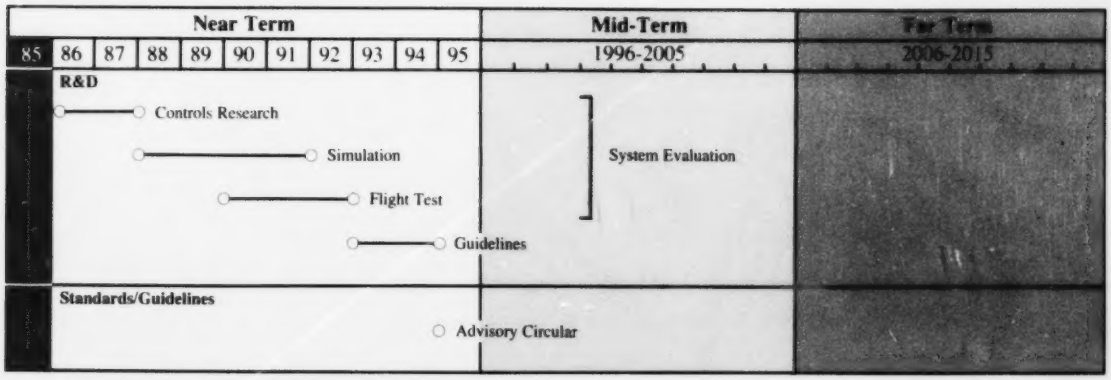
Recent Accomplishments

None

Related Projects/Activities

- Advanced Voice Recognition Systems (USAF)—the U.S. Air Force Flight Dynamics Laboratory (FDL) is developing voice recognition systems that will recognize a pilot's verbal commands.
- Advanced Cockpit Development (Boeing)—Boeing is developing and evaluating voice recognition systems that will recognize a pilot's verbal commands.
- General Aviation Applications (NASA-Langley)—NASA is developing voice recognition systems for general aviation that will recognize a pilot's verbal commands.

Schedule



14.16
Enunciators

Purpose

To determine the performance parameters of voice synthesis systems for providing highly intelligible speech in cockpit and control room environments in the transmission of operational data; to determine how voice messages can be used to augment existing alerting sounds (or vice versa); and finally, to study how voice messages from various sources (man and machine) can be prioritized appropriately.

Category

E—New Initiatives

Approach

Alternative techniques and previous work will be reviewed, and conceptual designs formulated. Simulations providing a wide range of speech parameters for evaluation will be developed. Simulations will be conducted with pilots and controllers in realistic operational environments, and flight tests will be performed. Enunciators will be integrated into the displays, and procedures for assisting traffic management will be developed, including warning sounds and radio transmissions.

Products

- Report on simulation evaluation of cockpit enunciator
- Report on flight test evaluation of cockpit enunciator
- Report on simulation evaluation of ATC enunciators
- Guidelines for cockpit enunciators
- Specification for ATC enunciators

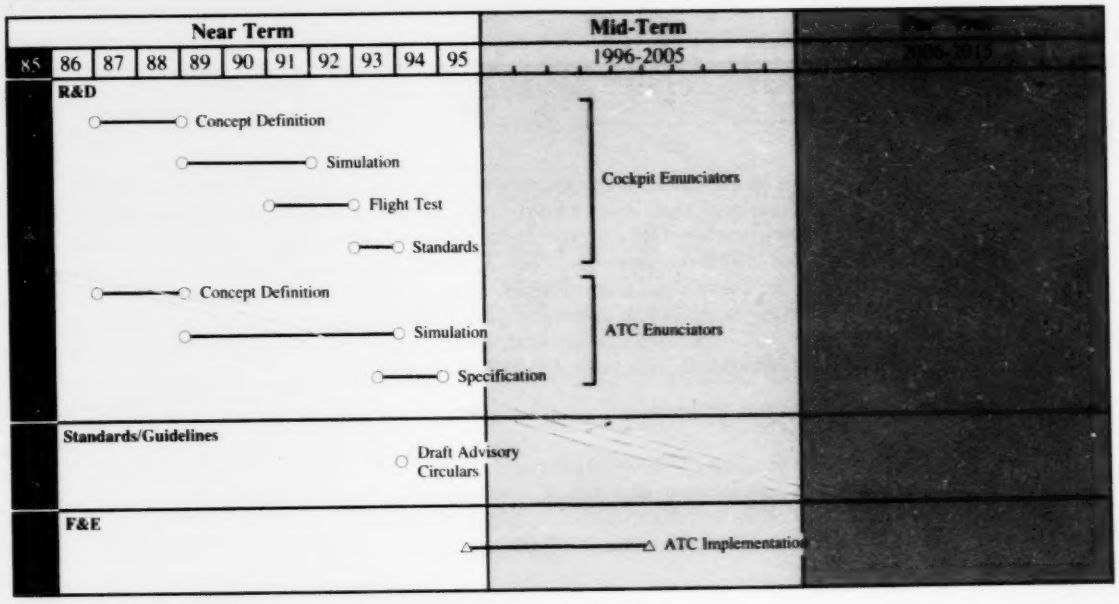
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Pilot Self-Briefing Terminals (FAA Technical Center)—uses voice synthesis techniques to brief pilots, for example, on weather conditions.
- Aircraft Alerting Systems Standardization Study (DOT/FAA/RD-81/38,I)—addresses the issue of excessive and nonstandard alerting systems in the cockpit.

Schedule



14.17
Voice Data Entry

Purpose

To monitor ongoing research in voice recognition technology, and develop techniques that will enable pilots and controllers to interface with data links and other cockpit/ATC equipment by voice at a high level of accuracy.

Category

E—New Initiatives

Approach

Research will be conducted on applications of voice recognition technology to cockpit and control room communications activities. Voice recognition concepts will be developed that will make possible high levels of recognition accuracy with different controllers and pilots using standard vocabularies. Simulations will be conducted that will determine equipment standards and establish the voice recognition parameters required for operation in the cockpit and control room environments. Guidelines will be developed for cockpit use. Voice recognition equipment will be developed and integrated into the control room procedures and into data link systems. Ways of improving communication radio voice quality will be studied, and the possibility of automatic ground-level recognition area radio link will be explored.

Products

- Report on concept definition studies
- Report on simulation evaluations of voice entry
- Report on flight test evaluations of cockpit voice entry
- Voice recognition equipment specification/guidelines

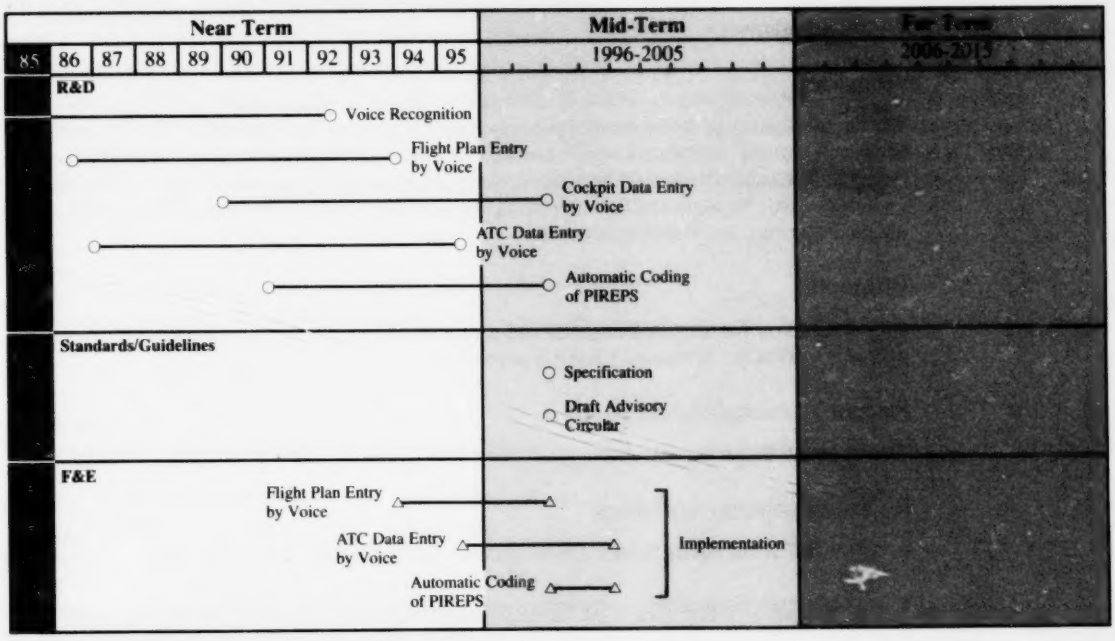
Recent Accomplishments

- Preliminary studies and simulations completed.

Related Projects/Activities

- Advanced Voice Recognition Systems (USAF)—the U.S. Air Force Flight Dynamics Laboratory (FDL) is developing voice recognition systems that will recognize a pilot's verbal commands.
- Voice Recognition Systems (Sikorsky Aircraft)—Sikorsky is evaluating voice recognition systems for rotorcraft that recognize a pilot's verbal commands.
- Advanced Cockpit Development (Boeing)—Boeing is developing and evaluating voice recognition systems that will recognize a pilot's verbal commands.

Schedule



14.18
CADM-Assisted Meteorological Applications

Purpose

To apply expert systems techniques for improving the ability of meteorological systems to detect and identify hazardous conditions reliably, and to characterize the location, motion, extent, and danger of these conditions so that appropriate controller and pilot actions for avoiding them can be recommended.

Category

E—New Initiatives

Approach

Efforts will continue on current expert system-based research on sensitive Doppler radars for use in the terminal area in detecting microburst wind shears associated with thunderstorm activity. The capability to detect gust fronts and frontal shears will be enhanced through the incorporation of other sensor inputs. Expert system techniques will be explored for improving the detection and characterization capability of LLWAS processors and wake vortex avoidance processors.

Products

- Specification for terminal Doppler radar processor
- Specification for enhanced LLWAS processor

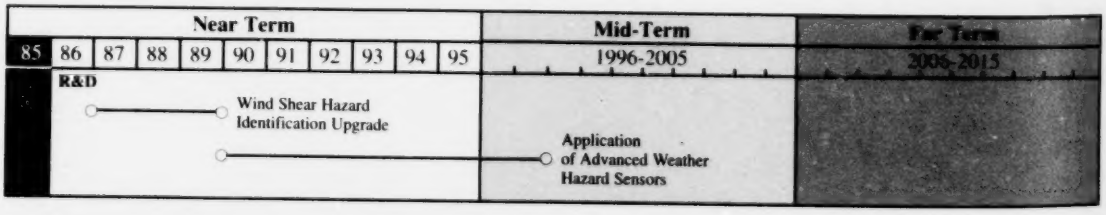
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Advanced Wind Shear Sensor Development—provides necessary wind shear information for an expert system.
- Wake Vortex Forecasting—identifies meteorological factors affecting wake vortices.
- Traffic Management System—provides functional specifications for an advanced TMS expert system.

Schedule



14.19
CADM-Assisted Air Traffic Control Techniques

Purpose

To apply expert system and knowledge-based system (KBS) techniques to air traffic control in an effort to improve the controller's decision making abilities and reduce the workload. The ultimate objectives are improved air safety, greater controller productivity, reduced delays, and increased capacity.

Category

E—New Initiatives

Approach

Those duties of the ATC controllers that are susceptible to improvement through the application of expert system and KBS techniques will be identified. Knowledge bases that will provide the controller with sound recommended actions during high workload conditions will be developed. There will also be an effort aimed at defining the necessary concepts and developing specifications consistent with currently planned programs, such as the AAS, AERA, and TMS.

Products

- Improved system delay model specification
- Position prediction KBS specification
- Merge strategy KBS specification
- Delay management KBS specification
- Conflict resolution KBS specification
- Advanced ATC KBS specification
- Flow control delay management KBS specification

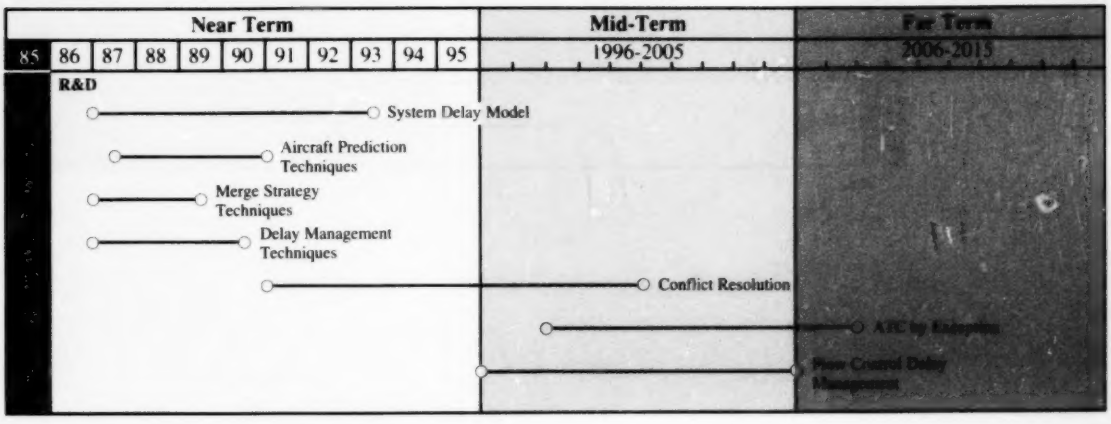
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Weather Processing—provides timely weather information for air traffic management.
- Advanced Automation System—develops functional specifications for expert system applications.
- AERA—develops functional specifications for expert system applications.
- Traffic Management System—develops functional specifications for expert system applications.

Schedule



14.20
CADM-Assisted Training

Purpose

To apply knowledge bases developed to assist controllers to the training of new controllers, traffic managers, and operations support and maintenance personnel.

Category

E—New Initiatives

Approach

Testbeds will be developed based on AI knowledge bases developed in the CADM-Assisted Air Traffic Control Techniques project, oriented to the needs of controllers, traffic managers, and operations support and maintenance personnel. These testbeds will be evaluated and improved if possible. Once they have been determined to be useful, they can be immediately employed for training.

Products

- Knowledge-based testbed for training ATC controllers
- Knowledge-based testbed for training traffic managers
- Knowledge-based testbed for training operations support and maintenance personnel

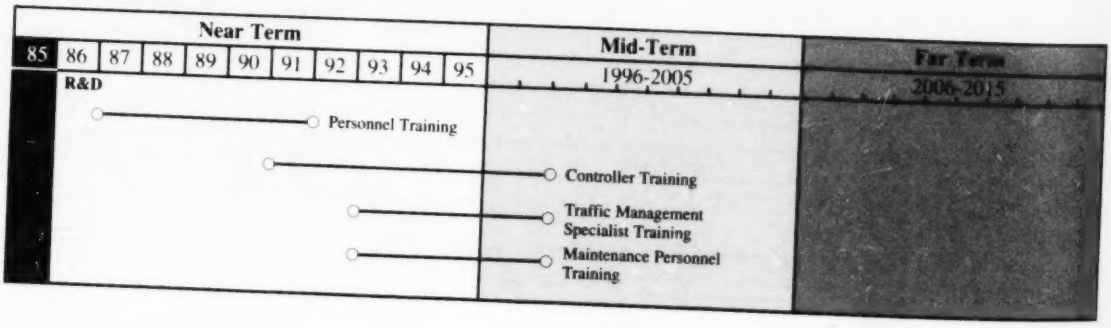
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- CADM-Assisted Air Traffic Control Techniques—as new techniques are specified for any area, CADM training is to be provided.

Schedule



14.21
CADM-Assisted Maintenance and Fault-Tolerant Equipment

Purpose

To apply KBS techniques and recently developed failure prediction techniques for improving the reliability of equipment, developing automatic diagnostic techniques, and developing specifications for fault-tolerant equipment.

Category

E—New Initiatives

Approach

Research will be conducted to explore the potential of failure prediction techniques. Automatic diagnostic methods will be developed based on these techniques that would enable routine maintenance procedures to replace equipment, modules, or parts before they fail. Specifications for fault-tolerant equipment will be developed based on similar work being conducted for the DOD.

Products

- Report on failure prediction evaluation
- Specification for automatic diagnostics
- Report on evaluation of fault-tolerant equipment techniques
- Specifications for fault-tolerant equipment

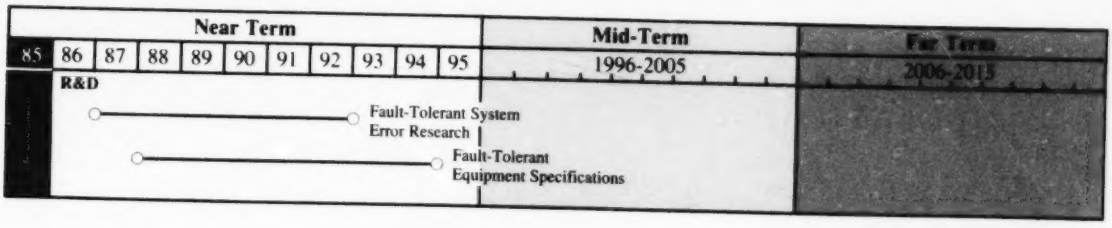
Recent Accomplishments

This is a new R,E&D project.

Related Projects/Activities

- Advanced Automation System—provides functional specifications for expert system applications.

Schedule



Appendix A
Matrix Identifying R,E&D Project Prerequisites

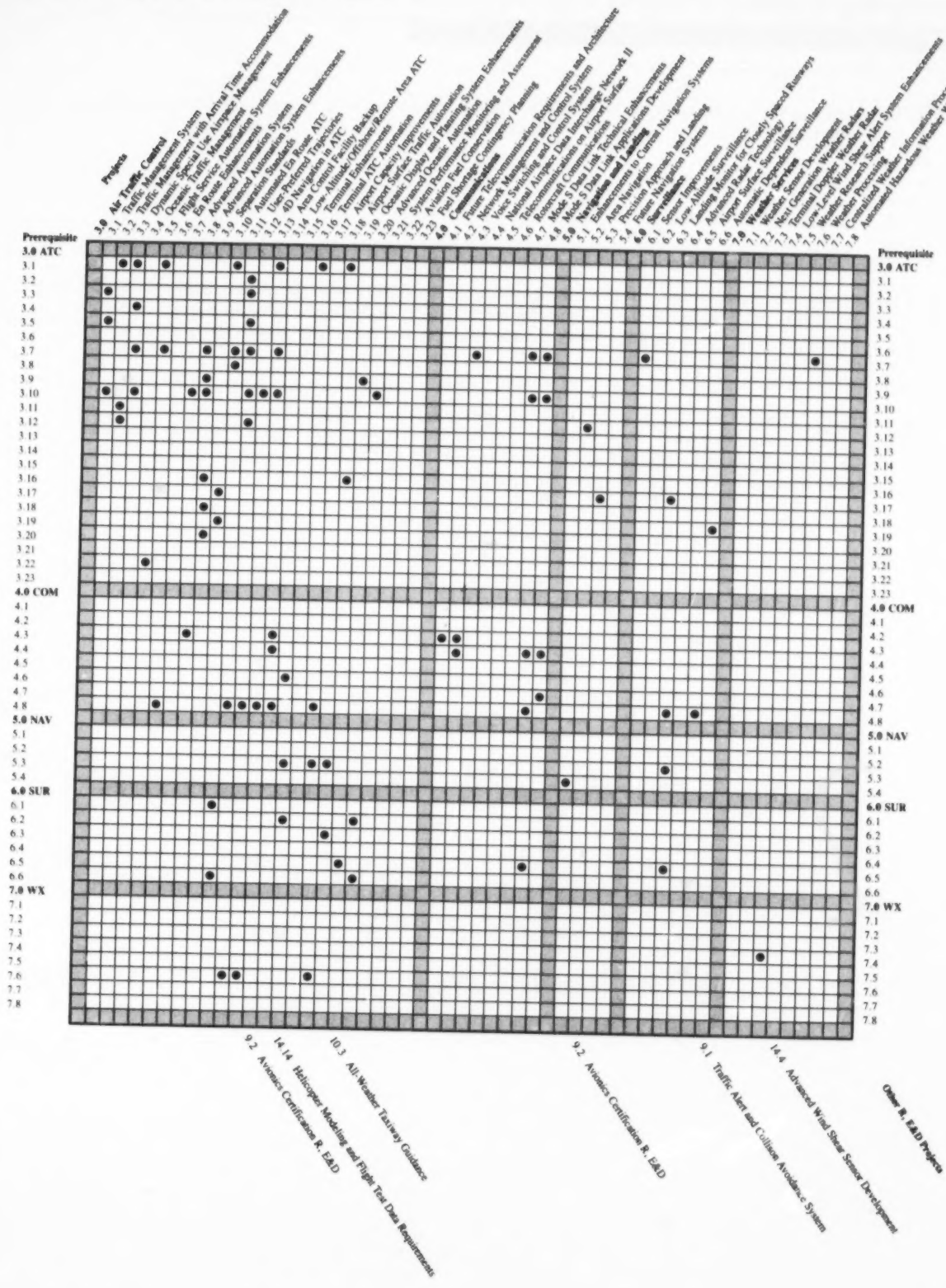
The matrix in Table A-I identifies the R,E&D project prerequisites for projects in the following chapters of the R,E&D Plan dealing with ATC, CNS, and weather services:

Chapter 3. Air Traffic Control
Chapter 4. Communications
Chapter 5. Navigation and Landing
Chapter 6. Surveillance
Chapter 7. Weather Services

Each project from the above chapters is assigned a column of the matrix, with the project number and title listed across the top. Projects identified as prerequisites for individual R,E&D projects have been listed earlier in project descriptions of the above chapters under Related Projects and Activities. These prerequisites are indicated in Table A-I by dots in each project column. Any other prerequisite projects are shown by project number and title at the bottom of each project column.

Indirect project dependencies, such as prerequisites of prerequisites, are not shown in this matrix. For example, the Weather Sensor Development (7.1) project is not shown here as a prerequisite for the Weather Processing (7.6) project, although it is a prerequisite for the AWOS project of the NAS Plan, which in turn, is a prerequisite for the Weather Processing (7.6) project and is identified as such in Chapter 7.

Table A-I
Matrix Identifying R,E&D Project Prerequisites


Projects
3.0 Air Traffic Control
3.1 Traffic Management System
3.2 Traffic Management with Arrival Time Accommodation
3.3 Dynamic Special Use Airspace Management
3.4 Oceanic Traffic Management
3.5 Flight Service Automation System Enhancements
3.6 En Route Enhancement System
3.7 Advanced Automation System
3.8 Advanced Automation System Enhancements
3.9 Separation Standards
3.10 Automated En Route ATC
3.11 4D Navigation in ATC
3.12 User-Preferred Trajectories
3.13 Area Control Facility Backup
3.14 Low-Altitude (Offshore/Remote Area ATC
3.15 Terminal Enhancements
3.16 Terminal ATC Automation
3.17 Airport Capacity Improvements
3.18 Airport Surface Traffic Automation
3.19 Oceanic Display and Planning System Enhancements
3.20 Advanced Oceanic Automation
3.21 System Performance Monitoring and Assessment
3.22 Aviation Fuel Conservation
3.23 Fuel Shortage Contingency Planning
4.0 Communications
4.1 Future Telecommunication Requirements and Architecture
4.2 Network Management and Control System
4.3 Voice Switching and Control System
4.4 National Airspace Data Interchange Network II
4.5 Telecommunications on Airport Surface
4.6 Research Communications
4.7 Mode S Data Link Technical Enhancements
4.8 Mode S Data Link Applications Development
5.0 Navigation and Landing
5.1 Area Navigation Enhancements to Current Navigation Systems
5.2 Precision Approach and Landing
5.3 Future Navigation Systems
5.4 Sensor Improvements
6.0 Surveillance
6.1 Low-Altitude Surveillance
6.2 Advanced Monitor for Closely Spaced Runways
6.3 Leading Advanced Radar Technology
6.4 Airport Surface Surveillance
6.5 Automatic Dependent Surveillance
6.6 Weather Services
7.0 Next Generation Weather Radar
7.1 Terminal Doppler Weather Radar
7.2 Low-Level Wind Shear Alert System Enhancements
7.3 Weather Processor
7.4 Weather Research Support
7.5 Centralized Weather Information Processing
7.6 Automated Hazardous Weather Warning/Alert Capability
7.7
7.8
Prerequisite
3.0 ATC
4.0 COM
5.0 NAV
6.0 SUR
7.0 WX
9.2 Avionics Certification R, E&D
14.14 Helicopter Modeling and Flight Test Data Requirements
10.3 All Weather Taxiway Guidance
9.2 Avionics Certification R, E&D
9.1 Traffic Alert and Collision Avoidance System
14.4 Advanced Wind Shear Sensor Development
Other R, E&D Projects

Appendix B
Evolution Matrices for NAS Services for CNS

Table B-I shows, in matrix format, the evolution of CNS services to be provided in the R,E&D Plan. The matrices are arranged by areas of CNS service (Communications, Navigation/Landing, Surveillance, and combined CNS systems) as a function of improvements to the NAS in the near term (1986-95), mid-term (1996-2005), and far term (2006-15).

The R,E&D projects, described elsewhere in Volume II, that are associated with each improvement are shown for reference. R,E&D projects for ground-based communications, navigation/landing, and surveillance are described in Chapters 4, 5, and 6, respectively; R,E&D projects related to the use of satellites for CNS services are described in Chapter 8.

Also shown in the matrices are the projected benefits to be derived from each improvement (PP—Provider Productivity, UP—User Productivity, C—Capacity, and S—Safety).

Table B-I
Evolution of CNS/Satellite Systems

Area	Near Term 1986-1995			Mid-Term 1996-2005			Far Term 2006-2015		
	Improvement	R,E&D Project (Number)	Benefit	Improvement	R,E&D Project (Number)	Benefit	Improvement	R,E&D Project (Number)	Benefit
Communications	Provide an improved all-digital architecture for ground-ground telecommunications (voice and data).	Future Telecommunications Requirements and Architecture (4.1)	PP UP	Use satellite technology to provide ground-ground voice and data communications to remote areas.	Future Telecommunications Requirements and Architecture (4.1)	PP UP	Evolutionary		
	Provide expanded data switching and network monitoring functions to the existing National Airspace Data Interchange Network (NADIN).	NADIN II (4.4)	PP UP						
	Provide an improved Voice Switching and Control System for ground-ground and air-ground voice communications.	Voice Switching and Control System (VSCS) (4.3)	PP UP	Provide an integrated voice and data communications system to the airport surface.	Telecommunications on Airport Surface (4.5)	PP UP			
	Provide ground-air communications in certain low-altitude and remote areas to support IFR helicopter operations.	Rotorcraft Communications (4.6)	PP UP	Use satellites to provide voice and data communications in low altitudes and remote areas.	Studies of CNS System Design Alternatives (8.3)	PP UP			
	Provide a Network Management and Control System for the NAS Interfacilitity Communications System (NICS).	Network Management and Control System (4.2)	PP	,Use satellite technology to provide ground-air data communications in oceanic airspace.	Studies of CNS System Design Alternatives (8.3)	PP UP	Use satellite technology to provide ground-air voice and data communications in CONUS.	Studies of CNS System Design Alternatives (8.3)	PP UP
	Provide initial applications of the Mtde S data link system (e.g., hazardous weather advisories, exchange of communications with aircraft on the airport surface).	Mode S Data Link Applications Development (4.8)	PP UP	Provide enhanced applications of Mode S data link to air-ground data communications services (e.g., automated clearances and weather updates to aircraft).	Mode S Data Link Technical Enhancements (4.7)	PP UP			
Navigation/ Landing	Provide avionics standards and data bases for area navigation systems.	Area Navigation (RNAV) (5.2)	PP UP	Develop methods for management of airborne navigation data bases.	Area Navigation (RNAV) (5.2)	PP UP			
	Develop operational procedures and criteria for the Microwave Landing System (MLS) to exploit complex terminal operations. Provide MLS enhancements (e.g., 360° Az, auxiliary data applications, offset azimuth, and transition to back azimuth).	Precision Approach and Landing (5.3)	PP UP	Develop operational procedures and criteria for the MLS enhancements.	Precision Approach and Landing (5.3)	PP UP			
	Integrate technologies and techniques for future navigation systems.	Future Navigation Systems (5.4)	PP UP	Evolutionary			Evolutionary		
	Permit use of GPS as a supplemental navigation system capable of supporting nonprecision approaches.	Utilization of GPS for Civil Air Navigation (8.1)	PP UP	Permit use of GPS as a sole means of navigation. Permit use of GPS as a limited precision approach aid.	Utilization of GPS for Civil Air Navigation (8.1)	PP UP S			

Surveillance	Provide improved surveillance accuracy and reliability using multisensor processing techniques, clutter rejection, and improved radars (ASR-9, Mode S, 3D, and 2D).	Sensor Improvements (6.1)	PP S	Provide improved radar target detection.	Advanced Radar Technology (6.4)	PP	Provide improved independent surveillance systems.	Advanced Radar Technology (6.4)	PP
				Provide independent surveillance coverage to airspace not covered by existing surveillance systems.	Low Altitude Surveillance (6.2)	UP			
				Provide dependent surveillance in low-altitudes, remote areas, and oceanic airspace.	Automatic Dependent Surveillance (6.6)	PP			
				Provide high-accuracy independent surveillance system necessary to support aircraft approaches to closely spaced parallel runways.	Landing Monitor for Closely Spaced Runways (6.3)	C S			
	Reduce separation standards for oceanic routes through an improved surveillance system.	Automatic Dependent Surveillance (6.6)	C PP UP S	Provide enhanced airport surface detection capability.	Airport Surface Surveillance (6.5)	PP UP			
CNS Systems	Evaluate techniques utilizing satellites for improved surveillance services.	Studies of CNS System Design Alternatives (8.3)	C PP UP	Evolutionary			Evolutionary		
	Develop integrated systems designs for extending CNS coverage and improving CNS services.	Satellite-Based CNS System Design Configuration (8.2)	C PP UP	Evolutionary			Evolutionary		

C—Capacity
S—Safety
UP—User Productivity
PP—Provider Productivity

Appendix C
Correlation Between NAS Plan and R,E&D Plan Projects

Table C-I contains the correlated pairs of projects that appear in both the April, 1985 NAS Plan and the 1985 R,E&D Plan. This table consists of only those projects that contain ongoing or planned R,E&D activities described in the NAS Plan, and that extend through the 1985 calendar year or beyond. The research phases of some of these projects are scheduled to end in the coming year according to the NAS Plan; however, the R,E&D Plan may extend or expand the associated research activities. The two specific cases in the R,E&D Plan that fit this category (B/C) are the Utilization of GPS for Civil Air Navigation in Chapter 8 and the LLWAS Enhancements in Chapter 7.

Table C-I
Correlation Between NAS Plan and R,E&D Plan Projects

1985 NAS Plan Page	NAS Plan Project Title	1985 R,E&D Plan Page	R,E&D Plan Project Title	R,E&D Project Number
I-4	Traffic Alert and Collision Avoidance System (TCAS)	138	Traffic Alert and Collision Avoidance System	9.1
III-30	Traffic Management System (TMS)	21	Traffic Management System	3.1
III-38	Voice Switching and Control System (VSCS)	72	Voice Switching and Control System	4.3
III-40	Advanced Automation System (AAS)	33	Advanced Automation System	3.7
III-42	Automated En Route ATC (AERA)	39	Automated En Route ATC	3.10
III-100	Flight Service Automation System (FSAS)	29	Flight Service Automation System Enhancements	3.5
III-102	Central Weather Processor (CWP)	121	Weather Processing	7.6
III-110	Automated Weather Observing System (AWOS)	111	Weather Sensor Development	7.1
III-114	Wind Shear Efforts (LLWAS)	117	Low-Level Wind Shear Alert System Enhancements	7.4
IV-57	Global Positioning System (GPS) Monitors	129	Utilization of GPS for Civil Air Navigation	8.1
IV-60	Microwave Landing System (MLS)	88	Precision Approach and Landing	5.3
IV-70	Weather Radar Program (NEXRAD)	113	Next Generation Weather Radars	7.2
V-38	National Airspace Data Interchange Network (NADIN) II	73	National Airspace Data Interchange Network II	4.4

Appendix D
R,E&D Project Indices

A consolidated list of all R,E&D projects described in this plan is contained in Table D-I in numerical order by chapter. The alpha character designation under "Category" indicates the types of products or services expected to result from the project activities as described in Chapter 1. Table D-II contains the list of R,E&D projects sorted according to the following categories:

- Category A—NAS Concepts. These projects are for R,E&D planning and related projects designed to keep the R,E&D Plan current.
- Category B—Direct Support of NAS Plan. These projects are ones in which R,E&D is currently ongoing, as indicated in the NAS Plan.
- Category C—NAS Enhancements. These projects will provide enhancements to the present and developing NAS.
- Category B/C—Direct Support to the NAS Plan with Enhancements. These projects have either ongoing or planned R,E&D activities incorporated in the NAS Plan and, in addition, contain activities not included there which will expand or extend NAS capabilities.
- Category D—Sustaining R,E&D Activities. These projects support development activities in areas such as aircraft safety, aviation medicine, and security.
- Category E—New Initiatives. These projects may lead to the application of recent advancements in technology and new ideas for many different aspects of aviation.

Table D-III contains an alphabetical list of all R,E&D projects described in the plan.

Table D-I
Numerical Index of R,E&D Projects

Chapter	Project Number	Title	Category	Page
2		System Studies		7
	2.1	NAS Development Studies	A	8
	2.2	Advanced Concepts Studies	A	11
3		Air Traffic Control		13
	3.1	Traffic Management System	B	21
	3.2	Traffic Management with Arrival Time Accommodation	E	24
	3.3	Dynamic Special Use Airspace Management	C	25
	3.4	Oceanic Traffic Management	C	27
	3.5	Flight Service Automation System Enhancements	B/C	29
	3.6	En Route Enhancements	C	31
	3.7	Advanced Automation System	B/C	33
	3.8	Advanced Automation System Enhancements	C	35
	3.9	Separation Standards	C	37
	3.10	Automated En Route ATC	B	39
	3.11	User-Preferred Trajectories	C	41
	3.12	4D Navigation in ATC	E	43
	3.13	Area Control Facility Backup	C	45
	3.14	Low-Altitude/Offshore/Remote Area ATC	C	47
	3.15	Terminal Enhancements	C	49
	3.16	Terminal ATC Automation	E	50
	3.17	Airport Capacity Improvements	C	52
	3.18	Airport Surface Traffic Automation	E	54
	3.19	Oceanic Display and Planning System Enhancements	C	56
	3.20	Advanced Oceanic Automation	E	58
	3.21	System Performance Monitoring and Assessment	D	60
	3.22	Aviation Fuel Conservation	C	62
	3.23	Fuel Shortage Contingency Planning	C	64
4		Communications		67
	4.1	Future Telecommunication Requirements and Architecture	C	70
	4.2	Network Management and Control System	C	71
	4.3	Voice Switching and Control System	B	72
	4.4	National Airspace Data Interchange Network II	B	73
	4.5	Telecommunications on Airport Surface	C	75
	4.6	Rotorcraft Communications	C	76
	4.7	Mode S Data Link Technical Enhancements	C	78
	4.8	Mode S Data Link Applications Development	C	80

Chapter	Project Number	Title	Category	Page
5		Navigation and Landing		83
	5.1	Enhancements to Current Navigation Systems	C	84
	5.2	Area Navigation	C	86
	5.3	Precision Approach and Landing	B/C	88
	5.4	Future Navigation Systems	E	90
6		Surveillance		93
	6.1	Sensor Improvements	C	95
	6.2	Low-Altitude Surveillance	C	97
	6.3	Landing Monitor for Closely Spaced Runways	E	99
	6.4	Advanced Radar Technology	E	101
	6.5	Airport Surface Surveillance	C	102
	6.6	Automatic Dependent Surveillance	E	104
7		Weather Services		107
	7.1	Weather Sensor Development	B/C	111
	7.2	Next Generation Weather Radars	B	113
	7.3	Terminal Doppler Weather Radar	C	115
	7.4	Low-Level Wind Shear Alert System Enhancements	B/C	117
	7.5	Weather Research Support	D	119
	7.6	Weather Processing	B	121
	7.7	Centralized Weather Information Processing	C	123
	7.8	Automated Hazardous Weather Warning/Alert Capability	C	124
8		Satellite Applications		127
	8.1	Utilization of GPS for Civil Air Navigation	B/C	129
	8.2	Satellite-Based CNS System Design Configuration	E	131
	8.3	Studies of CNS System Design Alternatives	E	133
9		Avionics		137
	9.1	Traffic Alert and Collision Avoidance System	B/C	138
	9.2	Avionics Certification R,E&D	D	140
	9.3	Airborne Wind Shear Detection	C	142
10		Airports		145
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	10.2	Airport Design and Configuration	D	149
	10.3	All-Weather Taxiway Guidance	D	150
	10.4	Airport Safety	D	151
11		Aircraft Safety		155
	11.1	Aircraft Systems Fire Safety	D	158
	11.2	Aircraft Crashworthiness	D	160
	11.3	Propulsion and Fuel Systems	D	162
	11.4	Aircraft Icing	D	163
	11.5	Airworthiness	D	165
	11.6	Environmental Impact Studies	D	167
	11.7	Regulatory Development Support	D	169
12		Aviation Medicine		171
	12.1	Agency Workforce Optimization	D	172
	12.2	Human Performance	D	174
	12.3	Protection and Survival	D	176
	12.4	Aeromedical Program Support	D	178
13		Aviation Security		181
	13.1	Concourse Security	D	182
	13.2	Bulk Explosive Detection	D	183
	13.3	Enhanced Bomb Detection	D	184
	13.4	In-Flight Bomb Response	D	185
	13.5	Security System Integration	D	186
14		Technology Development		189
	14.1	Wake Vortex Avoidance	C	197
	14.2	Wake Vortex Forecasting	E	198
	14.3	Rotorcraft Wake Vortex Avoidance	C	199
	14.4	Advanced Wind Shear Sensor Development	E	200
	14.5	Evolution of Controllers' Roles	C	201
	14.6	Guidelines for Controller Displays and Data Entry Devices	C	203
	14.7	Controller Workload Assessment	C	205
	14.8	Flight Crew Training Enhancements	C	207
	14.9	Behavioral Certification Criteria for Cockpits	C	208
	14.10	Advanced-Technology Cockpit	E	209
	14.11	Rotorcraft Display and Control Standards and IFR Requirements	C	211
	14.12	Visual Scene Performance Characteristics	E	212
	14.13	Motion System Performance Characteristics	E	214
	14.14	Helicopter Modeling and Flight Test Data Requirements	E	216
	14.15	Voice-Activated Cockpit	E	217
	14.16	Enunciators	E	218
	14.17	Voice Data Entry	E	220
	14.18	CADM-Assisted Meteorological Applications	E	222
	14.19	CADM-Assisted Air Traffic Control Techniques	E	223
	14.20	CADM-Assisted Training	E	224
	14.21	CADM-Assisted Maintenance and Fault-Tolerant Equipment	E	225

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Categorical Index of R,E&D Projects

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	2.2	Advanced Concepts Studies	11
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	3.5	Flight Service Automation System Enhancements	29
	3.7	Advanced Automation System	33
	3.10	Automated En Route ATC	39
	4.3	Voice Switching and Control System	72
	4.4	National Airspace Data Interchange Network II	73
	5.3	Precision Approach and Landing	88
	7.1	Weather Sensor Development	111
	7.2	Next Generation Weather Radars	113
	7.4	Low-Level Wind Shear Alert System Enhancements	117
	7.6	Weather Processing	121
	8.1	Utilization of GPS for Civil Air Navigation	129
	9.1	Traffic Alert and Collision Avoidance System	138
C		NAS Enhancements	
	3.3	Dynamic Special Use Airspace Management	25
	3.4	Oceanic Traffic Management	27
	3.6	En Route Enhancements	31
	3.8	Advanced Automation System Enhancements	35
	3.9	Separation Standards	37
	3.11	User-Preferred Trajectories	41
	3.13	Area Control Facility Backup	45
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	3.15	Terminal Enhancements	49
	3.17	Airport Capacity Improvements	52
	3.19	Oceanic Display and Planning System Enhancements	56
	3.22	Aviation Fuel Conservation	62
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	4.7	Mode S Data Link Technical Enhancements	78
	4.8	Mode S Data Link Applications Development	80
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	5.2	Area Navigation	86
	6.1	Sensor Improvements	95
	6.2	Low-Altitude Surveillance	97
	6.5	Airport Surface Surveillance	102
	7.3	Terminal Doppler Weather Radar	115
	7.7	Centralized Weather Information Processing	123
	7.8	Automated Hazardous Weather Warning/Alert Capabilities	124
	9.3	Airborne Wind Shear Detection	142
	14.1	Wake Vortex Avoidance	197
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	14.5	Evolution of Controllers' Roles	201
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	14.9	Behavioral Certification Criteria for Cockpits	208
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D		Sustaining R,E&D Activities	
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	11.1	Aircraft Systems Fire Safety	158
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	12.1	Agency Workforce Optimization	172
	12.2	Human Performance	174
	12.3	Protection and Survival	176
	12.4	Aeromedical Program Support	178
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	13.2	Bulk Explosive Detection	183

Category	Project Number	Title	Page
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	3.20	Advanced Oceanic Automation	58
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	14.19	CADM-Assisted Air Traffic Control Techniques	223
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Advanced-Technology Cockpit	14.10	209
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Aeromedical Program Support	12.4	178
Agency Workforce Optimization	12.1	172
Airborne Wind Shear Detection	9.3	142
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Airport Safety	10.4	151
Airport Surface Surveillance	6.5	102
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Automated En Route ATC	3.10	39
Automated Hazardous Weather Warning/Alert Capability	7.8	124
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Appendix E
Acronyms

AAS	Advanced Automation System
AC	Advisory Circular
ACARS	ARINC Communications Addressing and Reporting System
ACF	Area Control Facility
ACS	Office of Civil Aviation Security (FAA)
ADS	Automatic Dependent Surveillance
AERA	Automated En Route ATC
AFFF	Aqueous Film-Forming Foam
AFSS	Automated Flight Service Station
AGL	Above Ground Level
AI	Artificial Intelligence
AM	Amplitude Modulation
ARF	Aviation Route Forecast
ARINC	Aeronautical Radio, Incorporated
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASDE	Airport Surface Detection Equipment
ASO	Southern Region Headquarters (FAA)
ASOS	Automated Surface Observing System
ASR	Airport Surveillance Radar
ASRS	Airport Surface Radar Surveillance/Aviation Safety Reporting System
ASTA	Airport Surface Traffic Automation
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATCS	Air Traffic Control Specialist
AT&T	American Telephone and Telegraph
ATIS	Automated Terminal Information Service
AWOS	Automated Weather Observing System
AWP	Aviation Weather Processor
CADM	Computer-Aided Decision Making
CAMI	Civil Aeromedical Institute
CAT	Category
CDT	Calculated Departure Time
CDTI	Cockpit Display of Traffic Information
CEP	Central East Pacific
CFC	Central Flow Control
CFCF	Central Flow Control Function
CFR	Crash, Fire, and Rescue
CFWP	Central Flow Weather Processor
CID	Controlled Impact Demonstration
CNS	Communications, Navigation, and Surveillance
CONUS	Contiguous or Conterminous United States
CTOL	Conventional Take-off and Landing Aircraft
CWP	Central Weather Processor
CWSU	Center Weather Service Unit
DARPA	Defense Advanced Research Projects Agency
DF	Direction Finder
DFM	Departure Flow Metering
4D	Four-Dimensional
DME	Distance Measuring Equipment
DME/P	Precision Distance Measuring Equipment
DOD	U.S. Department of Defense

DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DUAT	Direct User Access Terminal
EDCT	Estimated Departure Clearance Time
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency
ERL	Environmental Research Laboratory
ERM	En Route Metering
EXCOM	Executive Committee
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FAR	Federal Aviation Regulations
FDL	Flight Dynamics Laboratory
F&E	Facilities and Equipment
FMS	Flight Management System
FPF	Fluoroprotein Foam
FRP	Federal Radionavigation Plan
FSAS	Flight Service Automation System
FSDPS	Flight Service Data Processing System
FSS	Flight Service Station
GA	General Aviation
GALE	Genesis of the Atlantic Low Experiment
GASP	General Aviation Safety Panel
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HF	High Frequency
HUD	Heads Up Display
IBM	International Business Machines
ICAO	International Civil Aviation Organization
ICSS	Integrated Communication Switching System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IME	Institute of Makers of Explosives
INS	Inertial Navigation System
JAWOP	Joint Automated Weather Observation Program
KBS	Knowledge-Based System
LDA	Localizer Directional Approach
LIDAR	Light Detection and Ranging
LIP	Limited Installation Program
LLWAS	Low-Level Wind Shear Alert System
LOFF	Loran C Flight Following
MALSR	Medium-Intensity Approach Lighting System with Runway Alignment Indicator Lights
MAPS	Mesoscale Analysis and Prediction System
MEA	Minimum En Route Altitude
MIST	Microburst and Severe Thunderstorm
MLS	Microwave Landing System
MMI	Man/Machine Interface
MNPS	Minimum Navigation Performance Standards

MOPS	Minimum Operational Performance Standards
MSAW	Minimum Safe Altitude Warning
MSL	Mean Sea Level
MTD	Moving Target Detector
NADIN	National Airspace Data Interchange Network
NAPRS	National Airspace Performance Reporting System
NAS	National Airspace System
NASA	National Aeronautics & Space Administration
NAT	North Atlantic
NAVSTAR	Navigation System for Timing and Ranging
NDB	Non-Directional Beacon
NDT	Non-Destructive Testing
NEXRAD	Next Generation Weather Radar
NICS	NAS Interfacility Communications System
NOPAC	North Pacific
NOAA	National Oceanic and Atmospheric Administration
NOSAM	National Oil Shortage Analysis Model
NPRM	Notice of Proposed Rule Making
NSF	National Science Foundation
NTSB	National Transportation Safety Board
NWS	National Weather Service
OAM	Office of Aviation Medicine (FAA)
OASIS	Oceanic System Improvement Study
ODAPS	Oceanic Display and Planning System
OFCM	Office of the Federal Coordinator for Meteorology
O&M	Operations and Maintenance
ORD	O'Hare Airport
OTH	Over-The-Horizon
PF	Protein Foam
PIO	Pilot-Induced Oscillation
PIREP	Pilot Report
PROFS	Program for Regional Forecasting and Observing Services
RCE	Radio Control Equipment
RCL	Radio Communications Link
RCMS	Runway Configuration Management System
R&D	Research and Development
R,E&D	Research, Engineering and Development
REIL	Runway End Identifier Light
RF	Radio Frequency
RFMS	Runway Friction Measuring System
RML	Radar Microwave Link
RMM	Remote Monitoring and Maintenance
RMMS	Remote Maintenance Monitoring System
RNAV	Area Navigation
RTCA	Radio Technical Commission for Aeronautics
RVR	Runway Visual Range
SARPS	Standards and Recommended Practices
SC	Special Committee
SFAR	Special Federal Aviation Regulation
SIMMOD	Simulation Modeling
SMF	Surface Measurements Facility

SPR	Strategic Petroleum Reserve
STEP	Service Test and Evaluation Program
STOL	Short Take-Off and Landing
STORM	Stormscale Operational and Research Meteorology
SUA	Special Use Airspace
SVR	Slant Visual Range
TACAN	Tactical Aircraft Control and Navigation
TATCA	Terminal ATC Automation
TCA	Terminal Control Area/Terminal Conflict Alert
TCAS	Traffic Alert and Collision Avoidance System
TCCC	Tower Computer Control Complex
TDWR	Terminal Doppler Weather Radar
TERPS	Terminal Instrument Procedures
TMS	Traffic Management System
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control Facility
TSC	Transportation Systems Center
TSO	Technical Service Order
UPT	User-Preferred Trajectory
USA	U.S. Army
USAF	U.S. Air Force
USN	U.S. Navy
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
VRS	Voice Response System
VSCS	Voice Switching and Control System
V/STOL	Vertical/Short Takeoff and Landing
VTOL	Vertical Take-Off and Landing
WCP	Weather Communications Processor
WMSCR	Weather Message Switching Center Replacement
WV	Wake Vortex
WX	Weather

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